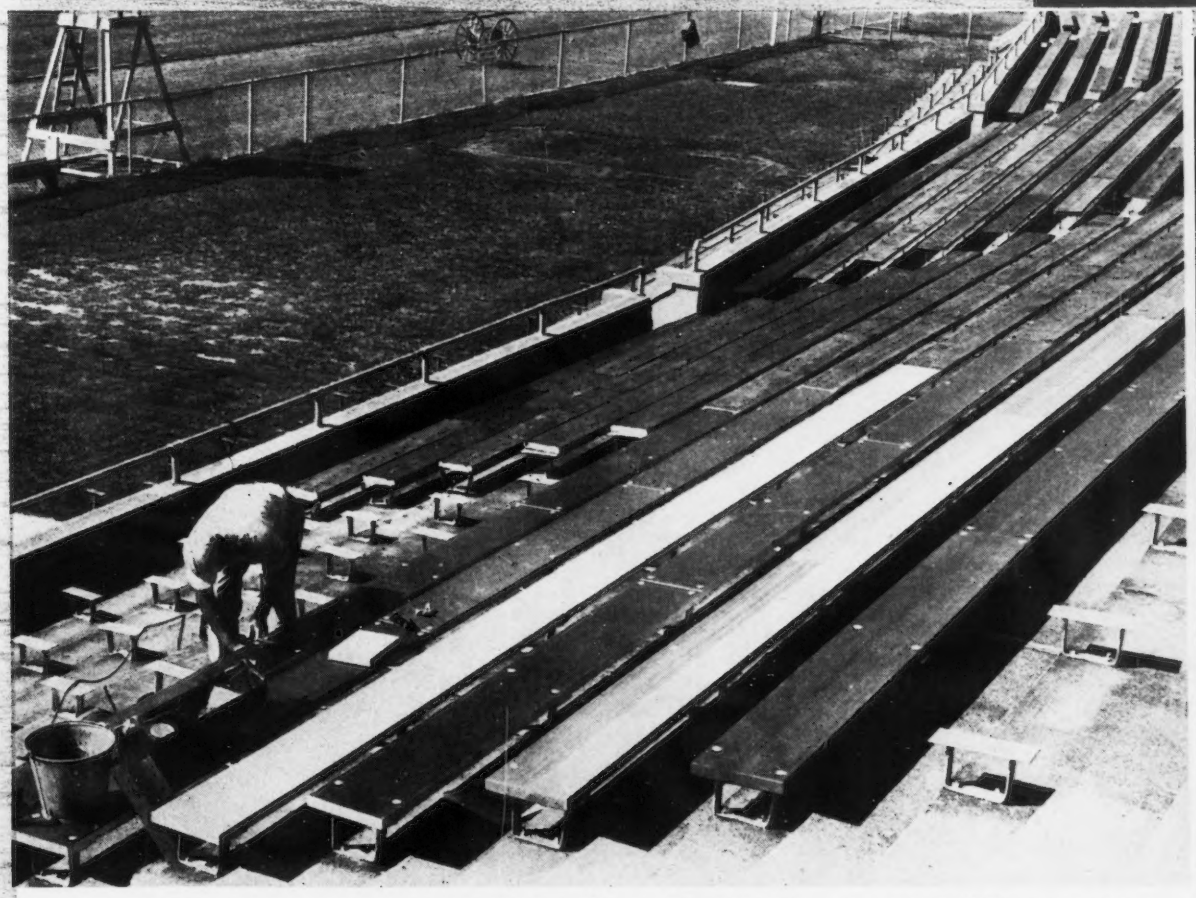
FOREST PRODUCTS JOURNAL

FOREST PRODUCTS RESEARCH SOCIETY



Paper-overlaid stadium seats were installed at Camp Randall, Wis., in 1954. USFPL says this is one example of many paper-overlaid lumber products ready for commercial adoption. See page 167.

Vol. XI, No. 4 1961 / APRIL

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MELURAC 305 melamine-urea adhesive consistently surpasses FHA, Commercial Standard CS 35-56 Type I, and Military Specification MIL-P-66A for waterproof bonds. It exceeds wet and dry shear values demanded by these specifications, and passes 10 cycles of 4-hour boiling (40 hours). In production, MELURAC 305 gives you these advantages: long working life and assembly time, moderate curing temperature (240° to 280° F.), freedom from staining. Use it in block flooring, exterior doors, exterior and marine grade plywoods, boats and sporting goods. For even greater water resistance, use straight CYMEL 401 melamine adhesive. Or use CYMEL 401 to upgrade the water resistance of urea adhesives and improve their assembly times. Write for technical information.

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Circle Item 1, Reader Service Form

FOREST PRODUCTS JOURNAL

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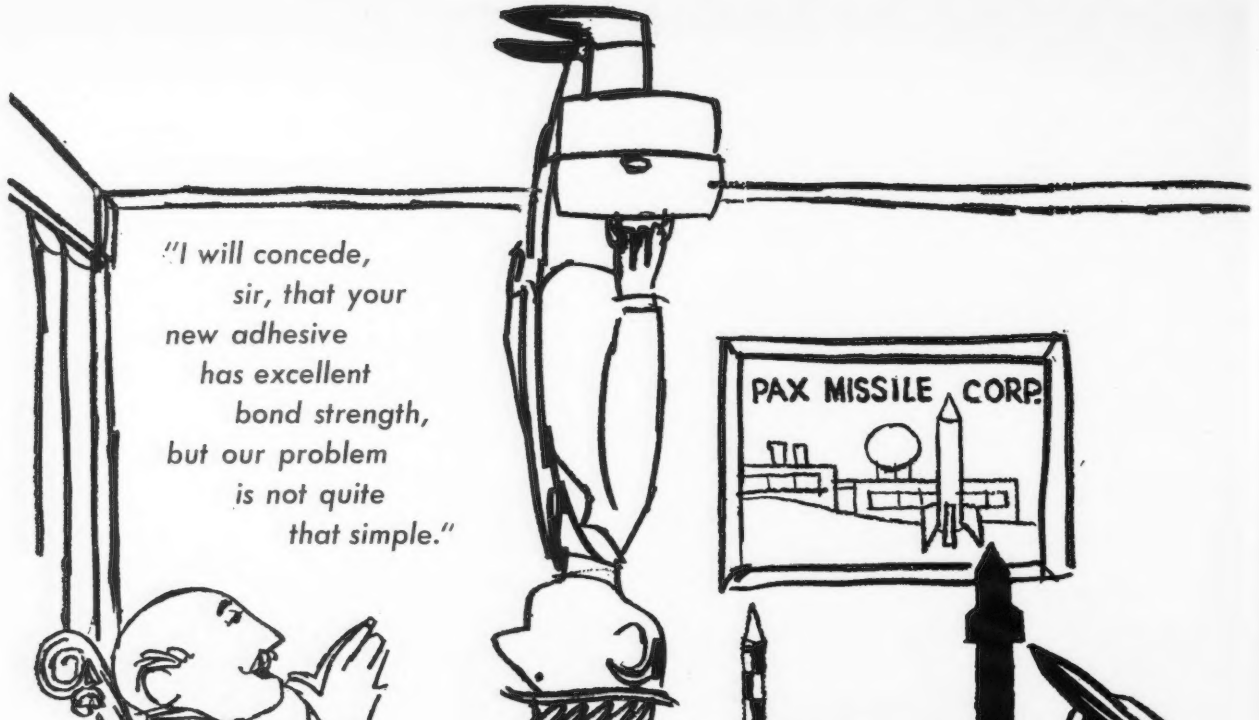
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FPRS News-Digest

CONVENTION HEADQUARTERS

Headquarters for the 15th Annual Meeting of FPRS will be the Kentucky Hotel, Louisville, Ky. Make your reservations now.

THEME OF FPRS 15th ANNUAL MEETING . . .

"Products Development — Keystone to Expanded Markets"

NATIONAL COMMITTEE FPRS 15th ANNUAL MEETING: Seated, left to right, Thomas Austin, local arrangements, Chester B. Stem Veneer Co., New Albany, Ind.; H. C. Moser, finance and budget chairman, Gamble Bros., Inc.; Harold Cook, vice chairman, Jeffersonville, Ind.; Carl Trinkle, general chairman, Baldwin Piano Co., Cincinnati, Ohio; C. W. Hill, assistant publicity chairman, General Plywood Corp., Louisville; standing, Ray Renaud, local arrangements, Wood Mosaic Co., Louisville; Charles Dieckmenn, local arrangements, Smith Cabinet Co., Salem, Ind.; R. L. Westenfelder, Paul Bunyan Hour, Carborundum Co., Indianapolis, Ind.; Robert Allen, local arrangements chairman, National Casein Co., New Albany, Ind.; A. F. Muschler, regional board member, Edward Hines Lumber Co., Chicago, Ill. Other committee members are J. R. Young, plant tours, F. A. Bade, publicity chairman; and L. C. Tingley, ladies program.

Louisville, Ky., the "Gateway to the South," will play host June 18–22 to the FPRS 15th Annual Meeting, which is expected to attract some 600 members and guests. Pre-convention reservations indicate the meeting will again have a distinct cosmopolitan flavor, with registrants from Australia, Canada, China, Finland, Germany, Japan, and the United States.

Program Developments

General Chairman Carl Trinkle, The Baldwin Piano Co., Cincinnatti, Ohio, reports that chairmen of the various committees are rapidly completing arrangements for a valuable and entertaining program. In keeping with FPRS Annual Meetings, a variety of social activities, ladies programs, luncheons, the FPRS Banquet, and a unique "Paul Bunyan" River Cruise are being scheduled.

Technical Sessions

Although the social side will not be neglected, FPRS has always taken pride in the fact that the annual meeting is a "working convention." This year will be no exception. Sixteen technical sessions have been confirmed to date. FPRS President–Elect D. K. Saunders, chairman of the technical program, reports that more than 50 papers, all slanted toward the general theme "Product Development—Keystone to Expanded Markets," have been confirmed to date.

All the authors are recognized authorities in their fields, many with international status. Titles and details of the technical program will be published in a forthcoming issue of the *Journal*.

Tentative Program

Registration facilities will be open Sunday, June 18, at the Kentucky Hotel, and registration will continue throughout the week.

The official program will start Monday, June 19, with the General Technical Session, and the Annual Business meeting will be held in the morning.

Technical Sessions for Division 1, Anatomy and Fundamental Properties; Division 7, Treatments and Coatings; and Division 10, Production Management, are now scheduled for Monday afternoon, and the traditional FPRS Paul Bunyan Hour will be held Monday evening.

The Official FPRS Luncheon, scheduled for Tuesday noon, will be preceded by Technical Sessions for Division 1, Anatomy and Fundamental Properties; Division 5, Particle and Fiber Processes; and a special session on veneer and plywood (tentative.)

Division Business Meetings will be held Tuesday afternoon, and the Division and Section Officers Advisory Committees will meet Tuesday evening.

Technical Sessions for Division 5, Particle and Fiber Processes; Division 8, Drying; and Division 11, Marketing are scheduled for Wednesday morning and afternoon.

The Executive Board will meet with Section Officers Wednesday noon, and the Official FPRS Banquet is scheduled for Wednesday evening.

Thursday will include Technical Sessions for Division 6, Glues and Gluing Processes; Division 4, Chemical Conversion; Division 3, Mechanical Conversion; and Division 2, Timber Production. Division Officers will hold a luncheon meeting with the Executive Board Thursday noon.

Plant tours are also being organized, but the schedule has not yet been confirmed.

Paul Bunyan Festivities To Feature Unique River Cruise

FPRS traditional festive evening—the Paul Bunyan Hour—will give members and guests a backward glimpse at a unique bit of Americana as they board the Steamer Avalon, an authentic paddle-wheeler straight out of the pages of Tom Sawyer, for a moonlight cruise down the Ohio River.

Scheduled for Monday, June 19, the Paul Bunyan River Cruise will feature dancing on the spacious ballroom deck, entertainment, and a variety of refreshments.

 See Reader Service Form, page 16–A

FPRS Ladies to Be Queens for a Day in the Home of the Sport of Kings

Highlight of the varied ladies program for FPRS 15 Annual Meeting will be a tour of the fabulous Kentucky Bluegrass Area, near Lexington. The Bluegrass Area with its magnificent farms of thousands of acres produces the world's finest race horses.

The farms, about 80 miles from Louisville, are the homes of such famous Kentucky Derby winners as Twenty Grand, War Admiral, Whirlaway, and Citation.

Trying to describe the beauty of the farms in June with their lush green grass, gleaming white fences and stables, banks of brilliant red roses—and the handsome, ever-gallant thoroughbreds brings to mind Irvin S. Cobb's comment when he was asked to describe the Kentucky Derby:

"If I could do that, I'd have a larynx of spun silver and the tongue of an annointed angel. . ."

In addition to the Bluegrass Area, Chairman Louis Tingley reports that tours are scheduled for Bardstown, location of My Old Kentucky Home, fabled inspiration of Stephen Foster's song. Also found in Bardstown is the Old Talbott Tavern, replete with slave block; St. Joseph's Cathedral, which houses master paintings that were gifts of King Louis Philippe; and the famed Trappist Monastery of Gethsemani.

In Louisville itself are several museums and galleries. Contemporary art may be found in Louisville House, the Art Center Gallery on South First Street near the University of Louisville; the Junior Art Gallery in the main library; the Arts Club in the Watterson Hotel; and the Little Gallery at Hadley Pottery, 1570 Story Avenue. The Filson Club houses the world's finest Kentucky history collection.

Downtown Louisville and surrounding areas offer unique shopping opportunities. One may find avant garde designs in pottery at Hadley Pottery, and the Bruce Fox Copper Works offer designs in copper from ashtrays to statuary. Fourth Street, which cuts through the heart of Louisville, constitutes the mainstream of Louisville's shopping district. It is one block from the Kentucky Hotel, which will be FPRS Convention headquarters.

May 1 Deadline For 1961 Hitchcock Award

The Forest Products Research Society and the Hitchcock Publishing Company, publishers of the Hitchcock's Woodworking Digest, jointly announce the rules for the 1961 Hitchcock Award. This Award will be given as recognition for outstanding individual research and/or career accomplishment at the professional and/or industrial level.

The Hitchcock Publishing Company will give annually to the Forest Products Research Society $500 as an Honorarium for the Award purpose; a full or part amount may be granted the awardee in 1961.

The 1961 Hitchcock Cash Award and an Award Certificate will be presented at the 1961 Annual Meeting of the Forest Research Products Research Society at the Kentucky Hotel, Louisville, Ky., June 18–22, 1961. The judges will be Dr. E. S. Harrar, Professor of Wood Technology, School of Forestry, Duke University, Durham, N.C.; Dr. E. A. Anderson, Department of Wood Products Engineering, State University, College of Forestry, Syracuse, N. Y.; Mr. A. D. Chapman, president of the Chapman Chemical Company; Mr. R. Bescher, assistant to vice-president and general manager, Koppers Co., Inc, Pittsburgh; and Mr. J. J. Byrne, Forest Service, U. S. Department of Agriculture, Washington, D.C.

All members of the Forest Products Research Society and the wood products industry may submit names of persons to be considered by the Board of Judges for the Award. Entries, in duplicate, must be submitted by May 1 to the Executive Secretary, Forest Products Research Society, 417 N. Walnut St., Madison 5, Wis. They should be 300 words long and not more than 350. The name and address of the person submitting the entry should be included as well as the name, address, and occupation of the person he chooses and his accomplishments which may be documented with supporting material.

Upper Mississippi Valley Plans Two Meetings in '61

At a program-planning session in Eau Claire, Wis., March 7, Upper Mississippi Valley Section officers made tentative plans for a spring meeting in central Wisconsin and a fall meeting in northern Minnesota. Both meetings will feature production tours of modern, progressive plants.

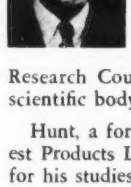
UMV officers are also working on a program to keep members better informed of developments within the area. Chairman L. A. Ropella, Marshfield, Wis., will name two members as section reporters to maintain a flow of information to the editor of the JOURNAL. As part of a plan to increase membership activity, members in strategic locations will be named to the section membership committee.

The planning session was attended by Chairman Ropella; Vice-Chairman S. H. Wise, Cloquet, Minn.; Trustee H. R. Emerson, Glidden, Wis.; and FPRS Executive Secretary K. E. Huddleston, Madison.

A Wisconsin blizzard prevented Secretary R. M. Marden and Trustees B. M. Granum and W. B. Wallin from attending.

Chairman Ropella also announced the appointment of John Neetzel, St. Paul, Minn., as treasurer to fill the term of J. A. Pence, who was recently transferred to St. Louis.

Philippine Research Council Awards Honor to G. M. Hunt



George M. Hunt, a founder and charter member of the Forest Products Research Society, recently became the first visiting American scientist to receive the outstanding achievement award of the National Research Council of the Philippines, top scientific body of that country.

Hunt, a former director of the U. S. Forest Products Laboratory, received the award for his studies on utilization of forest products and for distinguished service in the establishment and development of the Philippine Forest Products Research Institute.

Since 1954, Hunt has acted as a special advisor at the Research Institute under the sponsorship of the International Cooperation Administration. When he and Mrs. Hunt return to the United States in June, they plan to reside once again in Madison.

A world authority on wood preservation, Hunt was associated with the FPL as a chemist for 38 years, serving as director from 1946 until he retired in 1951. He is a graduate of the University of California.

See Reader Service Form, page 16–A

Glues & Gluing Division Seeks Active Business Meet, June 20

Richard F. Blomquist, chairman of FPRS Division of Glues and Gluing Processes, has emphasized the need for active participation by members at the annual business meeting of the division, which will be held in Louisville, Ky., June 20.

To help insure this participation and to lay the groundwork for future programming that will best suit membership interests, Blomquist recently surveyed all FPRS members who had indicated an interest in glues and gluing problems.

Based on more than 130 returned questionnaires, Chairman Blomquist has prepared a tentative 10-point agenda of items that will receive primary emphasis at the Annual meeting. Briefly, the 10 points are:

1) the need for better methods of translating research information so that industry can put it into immediate use; 2) the development of an action program for each of the subdivisions; 3) determine the proper place of the veneer and plywood group; 4) determine ways to improve technical sessions at future meeting; 5) determine a program of research needs and objectives in wood gluing research; 6) determine means to promote better gluing practices in industry; 7) plan future division activities on surveys, reports, abstracts, and bibliographies; 8) determine what gluing can do to help the wood industry meet competition; 9) plan a program of quality control and process control in gluing; 10) election of division officers.

Those not able to attend the Louisville meeting are encouraged to send their recommendations to Chairman R. F. Blomquist, care of *Forest Products Journal*, 417 North Walnut St., Madison, Wis.

Editors Note: See *Cross Section* for a personal appeal by Chairman Blomquist.

Pacific Northwest to Meet May 8–9 In Medford, Oreg.

Spring meeting of the Pacific Northwest Section, Forest Products Research Society, is scheduled for May 8–9 in Medford, Oregon, according to Don Burnet, of Crown Zellerbach Corporation, who is program chairman. Topics to be reported include protecting lumber during exterior storage, service experience with some 10,000 cross ties of 8 western species in main lines of the Southern Pacific Company, effect of some wood attributes on microtensile strength in Douglas-fir, new grades developed for ponderosa pine logs, and possible use of wood flour in pharmaceuticals.

Also, tentatively scheduled is a discussion of variation in thickness in dry veneer, accompanied by a film to show fundamentals of cutting action on a lathe. Problems in recovering turpentine and other chemicals from residues from pulping southern pine will be related also.

COMING EVENTS

Apr. 30–May 3: Semi-annual meeting, National Retail Lumber Dealers Assn., Shoreham Hotel, Washington, D. C.

★

May 4–5: Spring meeting, Southern Woodwork Assn., Grand Hotel, Point Clear, Ala.

★

May 8–9: Spring meeting, FPRS Pacific Northwest Section, Medford, Ore.

★

May 11–13: Seminar, Wood Office Furniture Institute, North Carolina State College, Raleigh, N. C.

★

May 15–19: Annual meeting, American Institute of Timber Construction, Desert Inn Hotel, Las Vegas, Nev.

★

May 17–19: Transportation conference, National Association of Furniture Manufacturers, Purdue University, Ind.

★

May 18–19: Wood seasoning clinic, jointly sponsored by West Michigan Wood Seasoning Clinic, Midwest Wood Seasoning Assn., and Grand Rapids Wood Seasoning Group, Grand Rapids, Mich.

★

May 18–20: Annual woodworking machinery exhibition, General Equipment, Inc., Statesville, N. C.

★

May 29–June 1: Annual meeting, American Wood Preservers' Assn., Banff Springs Hotel, Banff, Alberta, Canada.

★

June 1: Annual meeting, American Wood Preservers' Institute, Banff Springs Hotel, Banff, Alberta, Canada.

★

June 6–7: Midsummer meeting, National Oak Flooring Manufacturers Assn., Peabody Hotel, Memphis, Tenn.

★

June 13–14: International Conference on Methods of Direct Separation and Chromatography, Paris, France.

★

June 18–22: Annual Meeting, Forest Products Research Society, Kentucky Hotel, Louisville, Ky.

★

June 20–22: Annual meeting, National-American Wholesale Lumber Assn., Hotel Mark Hopkins, San Francisco, Calif.

★

June 21–22: Spring meeting, Northern Hardwood and Pine Manufacturers Association, Land O'Lakes, Wis.

Pallet Association To Meet In Canada

The 15th Annual Meeting of the National Wooden Pallet Manufacturers Association will be held at the Chateau Lake Louise in Lake Louise, Alberta, Canada, from July 2, 1961, through July 4, 1961. Approximately 100 persons from the United States and Canada are expected to attend this important industry meeting. Wooden pallets are an integral part of materials handling and automation.

The Annual Meeting will review the progress of NWPMA's trade promotion program for 1961, consider plans to develop larger markets for flat pallets and pallet containers, and will discuss the next phases of "The Coming Revolution in Packaging and Materials Handling." Research and development, improved sales techniques, new industry products, and plans for NWPMA's two (2) Pallet Users' Conferences to be held during 1961 will be among the subjects to be included in the meeting's business program.

Fast Drying of Red Alder Studied at Oregon Center

Increased production of kiln-dried red alder lumber and reduction in cost of drying may result from a study being made at the Oregon Forest Research Center in Corvallis, according to C. J. Kozlik, in charge of studies on wood seasoning. Preliminary results have indicated that drying time for red alder may be greatly reduced without loss in quality of wood.

Red alder has been the major species of the expanding hardwood industry in Oregon during recent years. Length of drying time and loss of quality of wood dried improperly have been serious problems to the lumber industry, stated Kozlik.

Past work at the Research Center indicated that red alder could tolerate kiln conditions more severe than those usually followed. Test charges of red alder were dried at temperatures up to 200° F. after an initial treatment to raise the temperature of the wood, Kozlik explained. A drying period following this initial treatment lowered the moisture content of red alder lumber to 7 percent, with degrade equal to or less than that obtained by present commercial methods of drying. Air velocity within kilns also has been studied. Red alder lumber of varying sizes is being dried as a final phase of this study.

Michigan Tech Offers Sawmill Short Course

On May 18 and 19, 1961, the Forest Products Research Division of Michigan Tech, together with the college's Institute of Extension Services, will offer another in a series of short courses designed to help sawmill operators increase profits through the use of modern technical and business methods. The course will be given at the College's Ford Forestry Center, L'Anse, Michigan. Further information can be obtained by writing to the Forest Products Research Division, Michigan College of Mining and Technology, Houghton, Michigan.

USP Plastic-on-Wood Era

A new line of decorative plywood wall paneling and doors sporting clear, thermoplastic armor was recently unveiled by U. S. Plywood in New York City. "This is the first time a clear, permanent plastic film has been successfully bonded to wood by the roll-laminating process," Gene C. Brewer, USP president said. USP also predicts that the new coating will make maintenance of wall and furniture installations obsolete.

More than three years of research and developmental work by U. S. Plywood and the Goodyear Tire and Rubber Company brought the product to market. Goodyear developed the thermoplastic film and is the supplier. The laminating film, called

Videne, has been derived from polyester resins developed during World War II. Some of the polyester resins, essentially produced from petroleum, air, and water, had interesting fiber-forming characteristics while others possessed unique film-forming qualities. Videne was first heralded in 1958, and today, after thorough testing and development, it provides the unusual surfacing offered in Weldwood Permagard, the name of U. S. Plywood's new line. It eliminates the necessity for multiple coatings typical of ordinary prefinishing operations, and it is the first laminating plastic designed specifically to provide a protective and economical prefinished surface for plywood. Maintenance-free durability, wear and stain resistance are qualities that company expects will lead to $4 million sales annually.

St. Regis Paper Co. Awards Graduate Fellowships

St. Regis Paper Company again offers two graduate fellowships in forestry in addition to five undergraduate scholarships in forestry. The fellowships are valued at $1,000 each and are given for one year.

Winners this year are Charles H. A. Little of the University of New Brunswick School of Forestry and James H. Gottsacker of the New York State University College of Forestry at Syracuse University.

Mr. Little is scheduled to receive a Bachelor of Science in Forestry this May and plans to study for the degree of Master of Forestry at the Yale University School of Forestry. Mr. Gottsacker is working toward a Master's Degree in Forestry Economics at the New York State University College of Forestry at Syracuse University. He is a native of Sheboygan, Wisconsin, and received a Bachelor of Science in Forestry from Iowa State University.

First Dinner Meeting Held By Carolinas-Chesapeake

First of a series of one-night dinner meetings was held by the Carolinas-Chesapeake Section on March 14, in Ocean Drive, South Carolina, according to an announcement by M. A. Taras, Section Chairman.

Guest speaker Walton R. Smith, Southeastern Forest Experiment Station, Asheville, N. C., presented a slide discussion of hurricane damage along the Carolina coast. His talk was followed by comments by architect David Macintosh, Charlotte, N. C.

Guests at the meeting were given a brief resume of the purpose of FPRS and were cordially invited to consider membership in the Society by Roy Carter, Professor of Wood Technology, School of Forestry, N.C. State College.

Chairman Taras reported that the next one-night meeting will be held in Washington, D. C. in April.

Great Lakes Section Meet May 25–26, Midland, Mich.

The Great Lakes Section of FPRS recently completed plans for a top-notch spring program that will feature technical sessions on acrylic coatings, theory of adhesion, urethane foams, and water-repellent preservatives.

The program will open Thursday evening, May 25 at the Midland Country Club, Midland, Mich., with a dinner meeting followed by a special address by Dr. R. H. Boundy, vice president in charge of research at Dow Chemical Co.

Friday, May 26, will be devoted to technical sessions with guest speakers who are outstanding in their fields—Robert Lalk, acrylic coatings; Dr. Turner Alfrey, adhesives; Dr. E. C. Galloway, flexible foams; and L. I. Weinbrenner, water-repellent preservatives.

The meeting will conclude with a special tour of the Dow Chemical Co., which is largely supporting the program.

For additional information contact: Program Chairman Henry Huber, Dow Chemical Co., Abbott Buildings, Midland, Mich.

Canada FPL's Reorganized

The Forest Products Research Branch will replace the Forest Products Laboratories of Canada and will undertake research embracing every aspect of forest products except that relating to the paper field. The Honorable Hugh John DFlemming, Minister of Forestry, announced the organization structure for the new Department of Forestry. The Department will comprise four branches: Administrative, Forest Research, Forest Entomology, and Pathology, and the Forest Products Research. There will also be a Forest Economics Division responsible directly to the Deputy Minister of Forestry.

The research conducted through the Ottawa and Vancouver Laboratories will be directed toward obtaining background information and data on the properties of Canadian woods, the development of new and better uses for wood products, improved manufacturing processes, and a more complete utilization of wood substances available from the forest. The branch also comprises an Industrial Liaison Service with field representatives covering the Maritimes, Western Quebec, Eastern Ontario, and the Prairies; and a Technical Information Service located in Ottawa to disseminate information embracing research developments and findings to the timber manufacturing and wood using industries of Canada.

European Timber Markets

Sawn softwood imports by European countries during the year 1960 should establish a new record for the post-war period. Consumption has reached high levels, wholesale merchants and retailers are rebuilding their stocks, and requirements have generally been met at prices which, though having risen from the low points reached in 1958–1959, still remain below the highest levels attained in 1957. These are some of the conclusions to be found in the latest "Timber Bulletin for Europe," published jointly by the Secretariats of the United Nations Economic Commission for Europe (ECE) and the Food and Agriculture Organization (FAO).

The demand for sawnwood remained generally strong into the third quarter, stimulated by high levels of all-around economic activity. Importers have rebuilt stocks while meeting increasing requirements, and producers of sawn wood have responded with great flexibility to the importers' demands. As the year progressed, these additional requirements moved prices of sawn goods upwards; in consequence, there were corresponding increases in the prices paid at the autumn log and stumpage sales.

The ECE Bulletin concludes that although the economic outlook in Europe is reasonably encouraging and high levels of industrial production and construction should continue, current growth rates do not appear likely to be sustained. Consequently, the 1961 forecasts, made by the ECE's Timber Committee in October, 1960, envisioning a slight falling-off in the sawn softwood trade for the forthcoming year, do not seem to require change.

NEW PRODUCTS and Literature

National Casein Poster

An eye-catching poster which reminds glue users to keep equipment clean for best gluing results has been announced by National Casein Company, Chicago manufacturer of woodworking glues.

Designed to help furniture manufacturers and other woodworking plants reduce glue failures which result from unclean gluing equipment, the poster should be posted near the gluing operation.

Circle Item 5

New Resin Catalog

Characteristics and properties of 13 resin base adhesives and animal glues developed for the woodworking industry are described in a new 8-page catalog. Catalog No. A-200, entitled "Woodworking Adhesives," also cites specific applications and advantages of each type of bonding material. Copies may be obtained from the Industrial Adhesives Division, Armour Alliance Industries, 161623 Armour Street N. E., Alliance, Ohio.

Circle Item 6

New Technical Portfolios Describe Crawler Cranes

Three technical portfolios describing features of the recently announced crawler crane models 525, 535, and 560 are now available from Harnischfeger Corp. of Milwaukee.

Complete operating specifications and complete detailed descriptions of the three models are presented. The literature contains 52 capacity charts, 13 dimensional drawings, diagrams, and photos of the units at work. Both English and metric figures are given. Copies are available from Harnischfeger's Construction and Mining Division.

Circle Item 7

Economical Roto-Barker

Wilco Machine Works, Inc., Memphis, Tenn., announces the Nicholson Model-C Accumat Roto-Barker which sells at approximately one-half the price of the higher production Roto-Barkers. This particular Roto-Barker can be supplied with roll or chain feed works. The same hydraulic powered self-opening tools that have proved to be successful on the Accumat debarkers will be used here also. It is especially well suited for sawmills needing a ring type debarker but not requiring a high feed speed machine and to whom economy is essential.

Circle Item 8

Control of Pine Tip Moth

Di-Syston, a systemic insecticide, is proving to be effective in giving one-year control of Nantucket Pine Tip Moth in pine seedlings and plantations. The Pine Tip Moth attacks all species of the Southern Pine with the possible exception of Longleaf Pine. The effects of attacks on Slash Pine are minimized by the copious flow of resin this tree species produces. The species most damaged by this insect are Loblolly Pine and Shortleaf Pine.

Completed test work and other work now in progress have shown that Di-Syston gives excellent and economical one-year control. Two of the larger pulp and paper companies plan full-scale use of this material in the near future. Di-Syston will be sent, upon request, in quantities large enough for test purposes on seedlings.

Circle Item 9

Automatic Nailers

Fasteners from ⅜ inch long to 2 inches long and more than 100 guns to drive them are illustrated in the new 16-page Spotnails catalog. Staples, "T" nails, finishing nails, and pines are illustrated and uses described. The catalog may be obtained upon request.

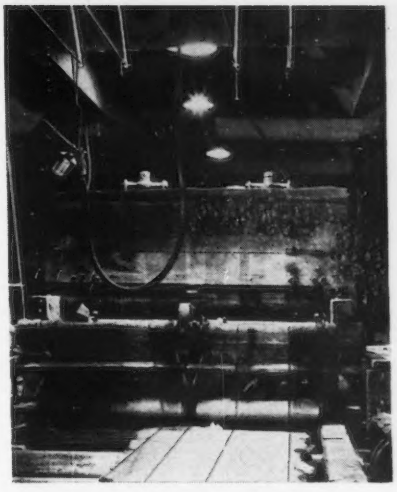
Circle Item 10

Electronic Lumber Trimmer

A "wood snooper" machine now being trial-run at the High Sierra Pine Mills plant at Oroville, Calif., detects and trims out, with "uncanny accuracy," specified wood characteristics not wanted in a grade, according to C. A. Rasmussen, research director of the 12-state association of lumber manufacturers. The "brain end" of the machine scans boards with an all-seeing electronic eye which also controls an integrated trim-saw that culls out undesired parts. The stock then passes through a finger-joint line where it is end-welded together again. Precision lumber of machine-made uniformity emerges in any length desired.

Rasmussen said that a second expanded and improved machine is being assembled now for a test-run at International Paper Company's pine mill at Weed, Calif. A complicated "memory system" is being built into this unit to augment "scanning" on both sides of the boards. Twenty automatic length stops and eight different width tolerances are to be masterminded by the machine while "eyeing" the stock for timeouts.

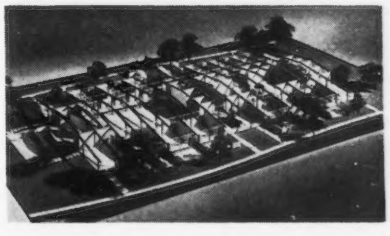
Circle Item 11



New Edger Guide

The Edgerlite shadow-line guide is essentially a visual aid and can be used for many things. Its outstanding application, however, is in conjunction with the edger in the mill. The shadow-line facilitates the setting of saws to obtain maximum production of highest grade lumber. Each shadow-line guide has an individual light and shadow bar for each saw. The position of the shadow bar is dependent on the position of the corresponding saw. As the edger saw lever is moved, changing position of the saw, a rocker arm with shadow bar, working through a gooseneck lever arrangement, is also moved, throwing shadows onto the cant at the place where the cut is to be made. This makes it easier for the edgerman to line up his board, and a certain amount of guesswork can be eliminated.

Circle Item 12



NLMA Issues New Booklet On School Design Program

A colorful, new booklet showing how schools can be designed to meet a variety of site and functional requirements has just been released by the National Lumber Manufacturers Association as part of a newly available, complete school design program.

Entitled "Blueprint For Better Schools," the booklet features ways of using wood to produce an esthetic, economical, efficient structure. The designs were developed by Cooper and Auerbach, A.I.A., of Washington, D. C.

A compact school design is authentically represented by eight-foot-long scale model of building designed for a limited budget, shown in the photograph. This plan is best adapted to relatively level site with limited area. Classrooms, all with outside exits, surround central core of administrative and service facilities.

Circle Item 13

McCulloch Introduces New Power Pruner

A revolutionary power tool that features an entirely new concept in pruning was introduced late in February by McCulloch Corporation, Los Angeles manufacturer of power chain saws and other 2 cycle engine products.

Marketed under the trade name of the McCulloch "ROTO-BIT Pruner", the new tool features a rotating cutter bit actuated by a shaft connected to a chain saw engine through a long aluminum pole. It enables the operator to conveniently reach limbs

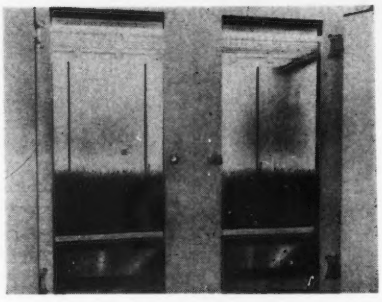
McCULLOCH ROTO-KIT PRUNER cuts limbs up to 16 feet or more from the ground. Prunes a 4 inch limb in 4 seconds. Attaches to a comfortable harness that enables operator to cut either side of tree without backswing.

PRUNING CUT made by revolutionary McCulloch ROTO-BIT "planes" the wood fibres, reducing chances of infestation.

up to 16 feet or more from the ground. Limbs up to 4 inches in diameter can be pruned in about 4 seconds, it is claimed.

According to McCulloch, the "ROTO-BIT Pruner" was developed in conjunction with the U. S. Forest Service Equipment Division to meet their requirements for a lightweight, completely self-contained power pruning tool. Research and development for such type of equipment has been underway during the past two years. The new McCulloch pruner is one result of these efforts, the company states, and will provide an efficient new method of pruning and release work for foresters, timber companies, tree surgeons, growers, municipalities and public utilities.

Circle Item 14



Controlled Environment Lab

A new controlled environment lab is earning the praise of scientists engaged in plant and animal growth studies. According to the manufacturer, Sherer-Gillett-Company, Marshall, Mich., their Model CEL 512–37 Controlled Environment Lab for biological research has overcome serious deficiencies commonly associated with plant growth rooms

The exclusive Sherer air flow design eliminates the need of a glass or plastic sheet barrier between the light tank and the plant growth bed which in previous equipment of this type was required because of the problem of hot air stratification in the upper levels of the room Thus, not only is a temperature control varying from + or —2° Fahrenheit within the growth zone held but, in addition, the maintenance and cleaning problem created by a barrier is eliminated

Circle Item 15

Compact Curta Calculator

The Type 2 Curta calculator is a new lightweight calculating machine introduced by the Curta Company for men who require a precise "on-the-spot" answer for every type of mathematical operation.

Combining the accuracy, speed and versatility of a large desk calculator with the portability of a pocket slide rule, the Curta has a capacity of 11 digits on the keyboard, 8 digits on the indicator dial and 15 digits (corresponding to 999 trillion) in the answer dial.

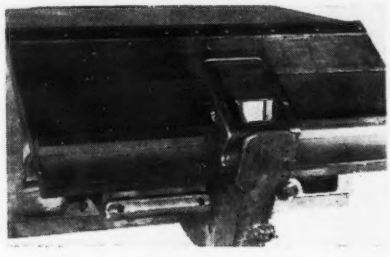
Precision made of stainless steel and high grade anodized aluminum alloys, the cylindrically shaped Curta is only 2 1/16 inches in diameter by 3 3/8 inches high (about the size of a fishing reel) and weighs 12 ounces. Easily held and operated in one hand, actual size shown above, the Curta is noiseless in operation, rust and corrosion-proof and does not require an external power supply.

Circle Item 16

New Face Shield

A new face shield that is especially valuable in protecting eyes, face, and under the chin is made to fit all safety helmets. Its primary use will be by the chemical and oil industries and wherever full-face coverage is required against acids, chemical sprays, foreign particles, or other fragments. It is lightweight and comfortable and features full, wide, and unrestricted vision and audibility. Complete information may be obtained upon request.

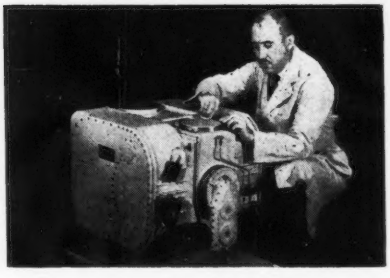
Circle Item 17



Trim Saw

A new trim saw combines operator's reflex action with a unique spring loaded table which makes it the fastest cut-off saw now available to flooring, furniture, and wood products manufactureres. The operator does not have to think about pushing a button, pulling a lever, or pressing a pedal. He positions the work, depresses the table, and makes the cut all in one simple motion. It has proved to be 60 percent faster under actual production conditions. The saw is manufactured by Lattner, and full particulars may be obtained upon request.

Circle Item 18



New Gas Turbine Engine

A model of a new 600 horsepower gas turbine engine is currently being developed by Solar Aircraft Company. The engine is expected to surpass piston engines in competitive applications. Among uses seen for the engine are vehicle and marine propulsion, generator, pump and compressor drives, and air-conditioning power source. It is aimed at filling an across-the-board need for military and industry.

Circle Item 19

LeTourneau Introduces New "Pacemakers"

A completely new line of "Pacemaker" diesel-electric tractors designed for heavy-duty pushing and dozing has been announced by R. G. LeTourneau, Inc. of Longview, Texas.

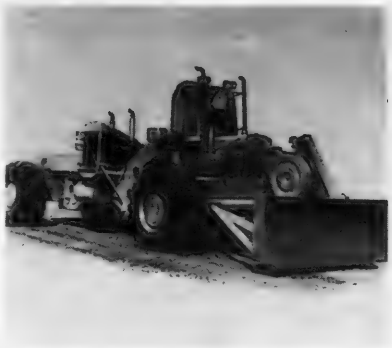
Like all equipment manufactured by the Texas-based firm, the new tractors are all-wheel drive machines with individually powered LeTourneau Electric Wheels for propulsion. In this system each wheel has its own DC electric motor and gear reduction built inside the rim. Electric generators—also manufactured by R. G. LeTourneau, Inc.—are direct coupled to the machines' diesel engines to power the motors.

Series K–53 Tug-Dozer

A three-wheeled tractor designated Series K–53 Tug-Dozer is the "smallest" of the new line (above left). It weighs approximately 80,000 pounds, is powered by a 420 hp diesel engine, and rolls on 75-inch diameter tires. A modification of this machine, the Series K–53F, is equipped with 89-inch tires and is intended especially for operation in sand and other areas where high flotation is necessary.

Log Stacker

An improved Series FJ Log Stacker, (above right), with electric powered tusk extensions also has been introduced by R. G. LeTourneau. The electric wheel unit, first introduced in 1957 and used to unload off-highway trucks in bites up to 22 tons has undergone several electrical and structural design improvements that now give it a 25 ton lift capacity. The electrically controlled and powered tusk extensions act like a giant hand as it unloads and sorts logs by length and species.



Four-Wheel Drive Tractors

Still in the 420 hp class, with an identical power plant, is the Series K–54 Power-Dozer—a four-wheel machine with 75-inch tires and a center-pivoted frame for steering. It weighs 86,000 pounds.

Giant of the new Pacemaker tractor line is the Series K–104 Power-Dozer (above center). It carries two 420 horsepower diesel engines to provide power for its four "A" size Electric Wheels—the most powerful regularly manufactured by the company.

Circle Item 20

Builders First To See Nail-Base Sheathing

Thousands of home builders got their first look at a nail-base sheathing a relatively new insulation board product, at the recent How-To-Do-It Carnival in connection with the annual National Association of Home Builders convention in Chicago.

Robert A. LaCosse, technical director of the Insulation Board Institute which sponsored the demonstration exhibit, said: "Home builders were especially impressed with the fact that insulation board nail-base sheathing allows the direct nailing of wood or asbestos cement shingles which saves up to $40 per house. Because nail-base is a high-density sheathing, it exceeds the FHA nail holding requirements thereby permitting the direct application of shingles."

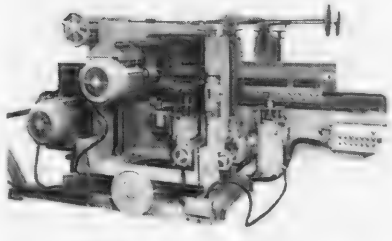
LaCosse also said builders were pleased to learn that the use of nail-base sheathing eliminates the need for corner bracing in home construction which saves builders up to an additional $35 per house. And, even though nail-base is a high-density insulation board product, it still provides twice the insulation value provided by the next-best competitive sheathing product.

Circle Item 21

Improve Panel Sizing

Two new machines, the Skinner Saw Feeder, which has been in operation about 12 months, and the Auto Panel Transfer, bring about a noteworthy improvement in panel sizing. They provide automatic feeding of the first and second sizing saws and thereby free the single operator so that he can oversee and attend to quality control. A bulletin describing the two machines is available from the Cardwell Machine Company.

Circle Item 22



Double-End Tenoner

Multiple grooving of high density insulation board has been speeded by development of new mechanical features on a Mereen-Johnson double-end tenoner. Innovations include combination of top and bottom grooving arbors; the upper arbor has depth regulating assembly for gaging depth of grooves from top surface of material. Grooves and profiles cut by the bottom arbor are gaged from the bottom surface. Center chains for carrying all pieces of material completely through the machine are another innovation.

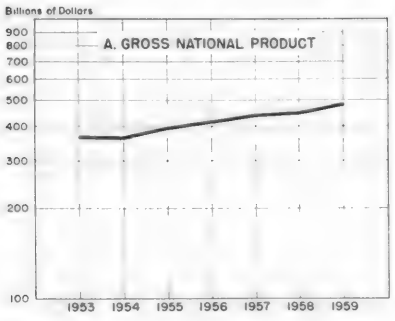
Circle Item 23

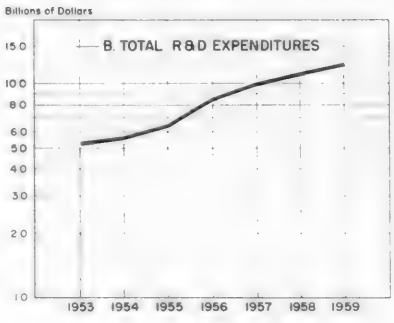
Waco Log Splitter

The Waco Aircraft Company, Troy, Ohio has added to their line of Lickity Log Splitters a new Model "L" which will split logs of any diameter in lengths up to 8½ feet.. This new, larger and more powerful machine is of sufficient length to split the 8½ foot logs by the use of a 3 foot extender and second part stroke. The 16-inch high splitting wedge is movable anywhere between 5 feet and 8½ feet on the frame. The two speed hydraulic action exerts approximately 5 ton push in "high" and when a tough spot needs extra persuasion, shifts automatically into "low" and 27½ ton push completes the splitting.

Circle Item 24

National Science Foundation Issues Report On R&D Spending Vs. Gross National Product





Expenditures for research and development in the Nation, estimated at $12.4 billion in 1959, were equal to 2.6 percent of the gross national product (GNP) for that year. During recent years this ratio has remained relatively constant, over 2 percent.

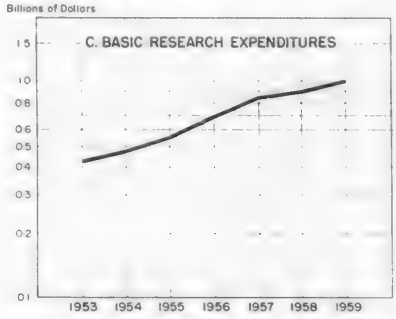
These data are included in a report released by the National Science Foundation which emphasizes that expenditures for research and development serve as one of the most productive stimulants to long-run economic growth. While research and development expenditures increased as a percentage of the gross national product from 1953 to 1959, the report noted the modest share they continued to represent in the total national effort.

Technical innovation and its subsequent diffusion in the economy can exert a steadily renewing long-run force on national investment and output, the report points out. The impact of innovations such as the transistor indicates that certain R&D efforts exert a multiplying long-run effect on the Nation's economy, frequently greater than the "multiplier" effects of investment in plant and equipment. In 1959, research and development expenditures represented about one-tenth of national investment.

The report further notes that research and development outlays by industrial firms were maintained at approximately the same level for 1957 and 1958, while capital expenditures on plant and equipment were cut back from $37 billion to $30.5 billion during this period of downturn in business activity.

The Foundation study states that technological progress, through new products, new processes, and new resources, is a key measure in obtaining long-run economic growth, achieving enrichment of living standards, and providing for national defense.

Basic research expenditures represented only two-tenths of one percent of gross national product in recent years. Since many research and development accomplishments derive ultimately from the basic research effort, the study suggests that it represents a relatively inexpensive means of accelerating economic growth.

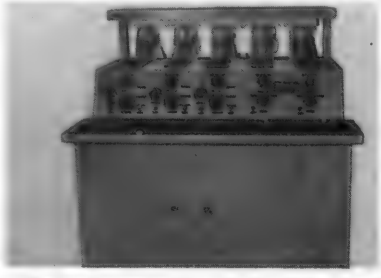


The Foundation study, "Research and Development and the Gross National Product," is reported in *Reviews of Data on Research & Development*, No. 26. Copies may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (Price. 10 cents).

Temperature Calibration

A new standard calibration bath apparatus for the accurate calibration of temperature actuated instruments and components has just been developed by The American Research Corporation.

The cabinet is actually equipped with five separate baths having individual temperature ranges as follows: — 30° F to + 40° F, + 35° F to + 105° F, + 100° F to + 170° F, + 165° F to + 235° F, and + 230° F to + 300° F. If required, these ranges can be extended to — 100° F. The cabinet is equipped with automatic proportioning controls which provide a basic accuracy of control within ± 0.1° F.



The baths are all welded stainless steel and have an interior capacity of 4 by 8 by 6 inches. Each bath has a mixer to assure uniform temperature, and the unit is completely self-contained. **Circle Item 25**

Here's what you can buy for cancer research

Scan the list below. Read the actual prices of equipment purchased with American Cancer Society funds. You'll see that *there are never any bargains in cancer research.*

Decide what you can afford to buy. Then mail your contribution with the coupon below to CANCER, c/o your post office.

RESEARCH PRICE LIST

5 dozen tissue culture tubes . . . **$5**

Food and care of 1500 mice for 1 day **$15**

1 micrometer **$19**

1 mouth rebreathing apparatus and nebulizer **$20**

1 instrument sterilizer **$50**

1 blood cell calculator, used in leukemia studies **$70**

4 days' maintenance of a cancer research bed **$100**

1 kymograph manometer . . . **$134**

1 isotope scanner **$250**

2,000 millicuries of radioactive iodine **$750**

½ gram of cobalt for radiation research **$6,000**

1 grant for the study of the role of hormones in growth, including the cause, prevention and treatment of cancer **$70,000**

100 medical training fellowships for 1 year **$500,000**

Grants to 5 scientists, each heading a cooperative five-year cancer research program . . **$1,000,000**

Mail this coupon to:
CANCER
c/o Your local post office

Attached is my donation of $_____ to fight cancer.

My Name_____

Address_____

City_____

State_____

AMERICAN CANCER SOCIETY

CROSS SECTION

... Voice of Membership

Fire Protection Meeting

More than 65 new and revised fire safety standards affecting a wide range of industrial and commercial interests will be up for action at the National Fire Protection Association's forthcoming annual meeting. The conference opens May 15 at the Statler Hilton Hotel in Detroit.

In line with NFPA procedures any interested party, whether or not a member of the Association, may speak for or against the proposals before action is taken at the meeting. NFPA standards are widely made the basis for ordinances and regulations relating to fire safety, and also extensively used by commerce and industry as the basis for good practice. The test of the proposed new standards and revisions of existing ones will be printed in the NFPA 1961 Advance Reports, a single volume of approximately 1,000 pages, available upon request.

Early Days of Logging Industry

A new book, "Yankee Loggers—A Recollection of Woodsmen, Cooks and River Drivers," by Stewart Holbrook, has been published recently by the International Paper Company. Aside from a vivid presentation of the industry's growth, the author describes the evolution of modern techniques of scientific forest management which constitute the foundation of the industry today.

Open Letter to Members of FPRS Division of Glues & Gluing Processes

Dear Colleague:

A Division within FPRS is only as strong as its members make it. As shown by the interest survey recently completed by the Executive Office, the Division of Glues and Gluing Processes received the highest rating of membership interest. This indicates the Division can be one of the strongest, most important units of FPRS. But, we must work to make it so.

Elsewhere in this issue, is a brief story on a tentative agenda for the Division's Annual Business Meeting in Louisville. Whether you plan to attend the meeting or not, please send any comments or suggestions you care to make to John McDonald, Editor of the *Journal*. Mr. McDonald will forward the comments to me.

For example, it has been suggested that the Division sponsor "production workshops" on specific industrial gluing problems. Where should we schedule it? On what problem? And, would *you* be willing to work on the program?

This is just one of the many suggestions and recommendations made by Division members.

If we are able to follow through on these recommendations, it will help our Division make valuable contributions to FPRS and to the entire wood-using industry. To do so, we need the help and services of many volunteers.

What would you like to work on?

R. F. BLOMQUIST, Chairman
Division Glues & Gluing Processes

Hoo-Hoo To Promote Forest Products Week

An inter-association committee will assist the International Concatenated Order of Hoo-Hoo in extending the effects of National Forest Products Week sponsored by Hoo-Hoo. The committee has made recommendations to Hoo-Hoo through the lumbermen's organization policy committee co-chairman, Martin Wiegand, St., Washington, D. C. The announcement also said the committee's first meeting produced assurances that there will be more emphasis on the week, to be observed in October, at the national level than last year.

If it's a question about wood preservatives...

See the man from WOOD TREATING

PENTACHOROPHENOL
Recognized as the leading preservative for protecting wood against decay and rot, termites and other wood-boring insects. Clean... won't stain... contains 5% Pentachlorophenol in a solvent base.

PRESSTREAT
Combination of PENTA **plus** water repellents for pressure treatment of lumber. Provides super above-and-below-ground protection against termites, other wood-boring insects, decay and fungus.

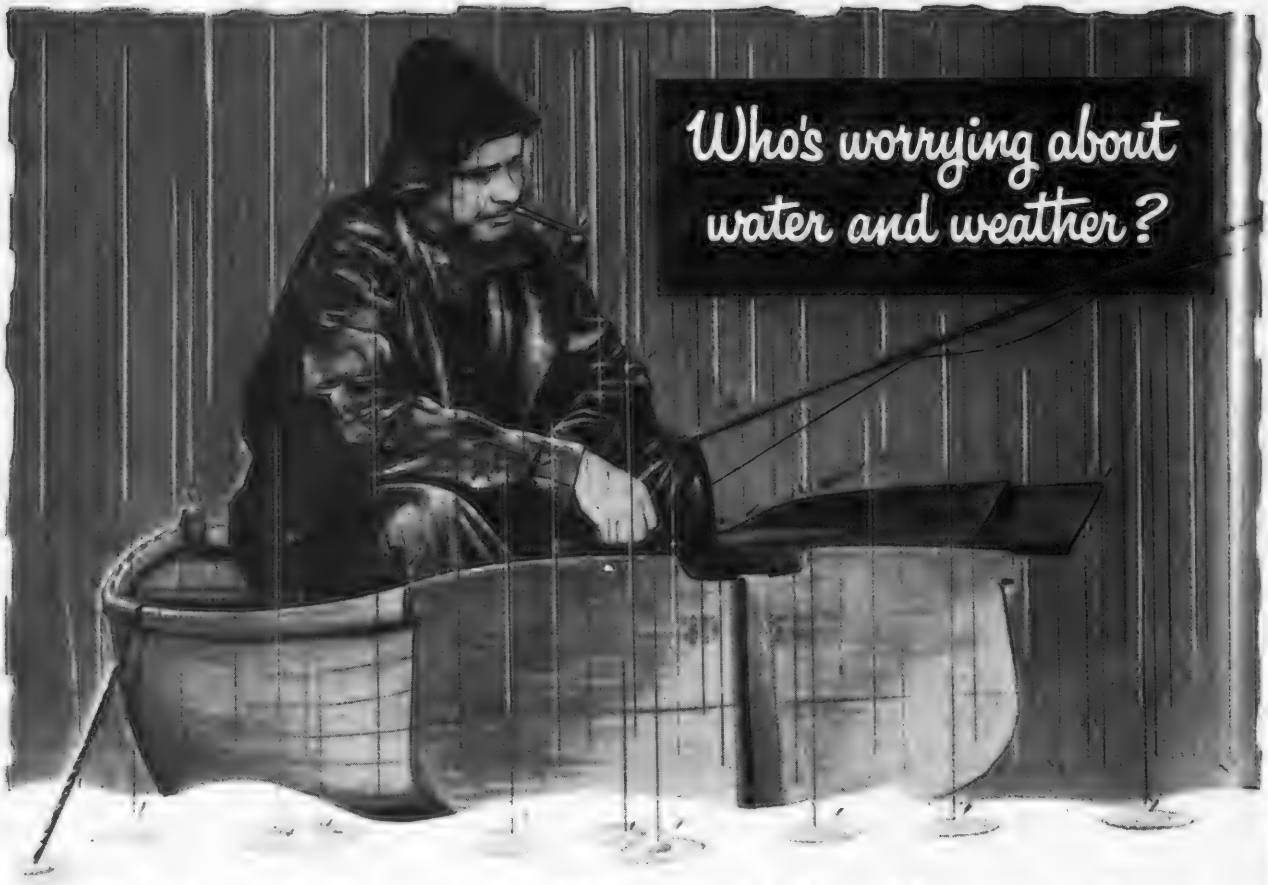
NOXTANE
Controls ugly blue-black sap stains and mold. Keeps lumber bright and clear... stops costly degrading. Contains no arsenic or mercury—non-irritating and dustless—resists leaching from rain.

WOODTREAT A
A 10% Penta emulsion paste. Gives maximum protection to standing poles, piling, cutoffs, structural timbers. Applied by hand scoop, brush, paddle or mechanical spray. Clean to handle... not highly toxic.

TECHNICAL COUNSEL
Experienced specialists **plus** the most modern and complete laboratory facilities, are available for counsel and help on any wood preservation problem.

For more information, write or phone...
Wood Treating Chemicals Co.
3137 Southwest Ave. • St. Louis 10, Mo.

WOOD TREATING



National Casein's R3 provides the most waterproof and weatherproof bond obtainable!

National Casein R3 is used also as a fortifier for Urea Resin glues where greater water and craze resistance is desirable. Having trouble meeting requirements of Spec. Mil-A-397B—ask the National Casein office nearest you for samples of "R3" and technical help in adapting it to your glue line. No obligation.

Waterproof . . . boil-proof . . . mold-proof—National Casein's R3 Resorcinol Resin Glue is recommended for any product made of wood that is destined for outdoor use under extraordinary conditions of water, weather and humidity.

National Casein's R3 Resorcinol Resin Glue is used for cold press work at 75° F. It is used also for hot press work and high frequency gluing, because it is thermo setting.

For aircraft and marine grade plywood . . . laminated timber construction . . . paneling and structural units for prefabricated housing, and for bag moulding construction you will find National Casein's "R3" positive assurance of your product's performance.

National Casein

National Casein Company, 601 W. 80th Street, Chicago 20, Illinois
National Casein of New Jersey, Broad & Fulton Streets, Riverton, New Jersey

Circle Item 27, Reader Service Form

FPRS FOREST PRODUCTS JOURNAL VOL. XI, NO. 4 APRIL, 1961

Paper Overlaid Lumber

BRUCE G. HEEBINK
Forest Products Laboratory,[2] Forest Service
U. S. Department of Agriculture

Industry has not generally adopted paper overlays for lumber siding, shelving, facia board, and similar products. USFPL experts say more work needs to be done but results so far are so encouraging, they feel the process is ready for commercial production.

AN EVALUATION BASED ON 8 YEARS OF USFPL RESEARCH

OVERLAID LUMBER is not a new concept. In 1932, research workers at the U. S. Forest Products Laboratory glued paper to southern yellow pine in an effort to improve its paint-holding characteristics (1)[3]. Thin, unsized tissue and heavy kraft paper were applied with water-resistant animal glue, the best available then. Since these glues were not waterproof, the paper peeled off eventually. The tests demonstrated, however, that paper could greatly improve the paint performance of heavy softwood with pronounced summerwood bands.

The development of synthetic resin adhesives shortly before World War II renewed interest in paper overlays. During the war, Forest Products Laboratory scientists in cooperation with a paper manufacturer developed resin-impregnated overlays for veneer and plywood.

Speculation on the possibility of gluing resin-impregnated overlays on solid wood with durable adhesives was a natural outgrowth of the success of these overlays on plywood and veneer. Overlaid plywood is now accepted for, among other things, exteriors of prefabricated houses and concrete forms, and overlaid veneer is widely used for shipping containers (3). But could a paper overlay withstand the stresses of shrinking and swelling of thick lumber? Could such unsightly defects as knots, pitch pockets, and splits, be permanently masked? Could a paper overlay reduce swelling and shrinking of lumber across the grain of the wood? Some of these questions have been answered by work at the Forest Products Laboratory during the past 8 years (5).

There are two broad classifications of overlaid-lumber: 1) panels that are completely hidden, such as sheathing and roof boards, and whose surface appearance is therefore of little consequence; and 2) products, such as siding and shelvings, whose surfaces are exposed, either painted or unpainted.

In the last few years the lumber industry has progressed in the development of an overlaid lumber sheathing and roof board panel. This type of material has been commercially available for about 3 to 4 years on the West Coast, it is now available in the Midwest. Meanwhile, the Forest Products Laboratory has concentrated almost entirely on products whose surfaces are exposed, or the second classification. Material requirements differ widely in the two product classes. The first utilizes essentially low-quality material and is overlaid with paper that has a very low resin content and is applied with the cheapest adhesives. The second class requires higher quality material, but it demands a higher price, since it competes with high-quality lumber and sometimes materials entirely out of the lumber field.

Characteristics of Overlay Papers

For experiments on the overlaying of lumber, resin-impregnated papers

The Author: Bruce Heebink is a mechanical engineering graduate of the University of Wisconsin and has been with the U. S. Forest Products Laboratory since 1934.

[1] Those cooperating in the evaluation of overlaid materials were: The Central States, Rocky Mountain, Southeastern, and Southern Forest and Range Experiment Stations; the University of Wisconsin, the Iron Range Resources and Rehabilitation Commission of the State of Minnesota; and the Southern Pine Association.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to Literature Cited at the end of this report.

A condensed version of this paper was presented at the Pacific Northwest Section Meeting, October 18 in Tacoma, Wash.

previously developed at the Forest Products Laboratory as overlays for plywood were used. These papers are reasonably high in strength whether dry or wet.

One overlay paper was made from a fairly well hydrated northern kraft pulp blended in the beater with about 20 percent of water-dispersible phenolic resin. After the resin had cured, the sheet thickness was about 0.018 inch and the weight about 70 pounds per 1,000 square feet. Other papers were made of similar pulp, but the resin was applied in a secondary impregnation operation. By variation of the thickness, density, blends of fibers, pulping processes, types of resin, methods of resin treatment, and degree of cure of the resin, the basic properties of overlay papers can be modified considerably. The various papers used in overlaying lumber are described in the Table.

Overlay papers for lumber should be high in tensile strength in one direction in order to restrain the swelling stresses of wood when it is exposed to moisture. It is equally important that the paper be extensible enough to stretch without rupture since the lumber becomes wider with increase in moisture content. Since wood shrinks upon drying, the paper must be compressible without developing unsightly compression failures.

Early experiments indicated that tensile failure of the overlay was not so serious a problem as anticipated. A greater problem evolved in compression failure (2). The resin adds tensile strength to paper, especially when wet; but usually the tensile strength of paper is considerably higher than its compressive strength.

The predominant requirements for strength of overlay papers are still not established, and further study is needed. It can be assumed however, that the elastic properties of paper, as well as the ultimate properties of tension and compression, are fundamental to its performance as an overlay.

Paper, like wood, has a predominant grain direction, but usually to a lesser degree. The degree of anisotropy can be controlled within limits in order to develop strength in the needed direction. Generally, paper can be stretched farther without rupture in its cross-machine direction, but its tensile strength is greater in the machine direction. These characteristics can be utilized either by proper orientation of paper with the wood grain, or be altered, within limits, in the papermaking operation.

An overlay should not only be evaluated for strength and elasticity but also for its ability to mask defects and its scuff resistance. Machining characteristics should also be studied; indications are that papers with appreciable amounts of resin (more than 10 percent) will cut clean, with little peeling or "fuzzing" of the paper. Although the overlay requirements for lumber are still not defined completely, the fiber-resin combinations are versatile, and the needs for a specific overlay probably can be met by properly blending and processing the components.

Description of Overlaid Lumber

The overlaid lumber used in most of the exploratory tests at the Forest Products Laboratory consisted of the lower common grades of western white pine, ¾ inch thick, overlaid on both sides with a resin-impregnated kraft sheet about 0.015 to 0.020 inch thick. Open defects, such as knotholes, were plugged.

The standard overlay sheet contained about 20 percent of water-dispersible phenolic resin added at the beater. The sheet was fully cured before it was applied to the lumber. The overlay was bonded to the lumber base (machine direction of paper parallel to wood grain) with a typical acid-catalyzed phenol-resin adhesive that set at room temperature using a cold press at a pressure of about 100 pounds per square inch which was maintained for at least 4 hours at 70° to 80° F.

In some cases, however, the procedure was varied to tailor-made material for specific experiments. For example, some overlaid test pieces were made with the predominant fiber direction of the paper at a right angle to the grain of the wood, with other adhesive formulations (some requiring a hot press), with other species, and with different grain orientations in the lumber base.

Dimensional Properties

All wood and wood-base materials change in dimension as they pick up and give off moisture. When dissimilar materials, such as resin-impregnated paper and lumber, are bonded together with a rigid glue line, and the resultant composite is allowed to change moisture content, stresses are set up if the dimensional properties of the two materials differ. The resultant dimensional movement in width and length of the composite is a compromise between the unrestrained dimensional movement of each material. It is further complicated by modulus of elasticity, rate of vapor absorption and transmission, and other factors.

The unrestrained dimensional movement of various sheet or board materials can be determined by equilibrating typical samples at various relative humidities and carefully measuring the dimensional changes. This was done for all overlay papers used in this study and also for some of the species of lumber investigated. Figures 1 and 2 show dimensional changes in two directions—for one of the resin-impregnated papers, and in width for ponderosa pine and red oak. The paper is considerably more stable in the machine direction than in the cross-machine direction. The greatest dimensional movement is exhibited across the grain by the two species of lumber. When the lumber is overlaid on both sides with the paper, the dimensional movement of the composite (across the grain of the lumber) is between that of the paper and that of the lumber

PROPERTIES OF OVERLAY PAPERS

Machine Run No.	Pulp furnish	Phenolic resins: Type	Phenolic resins: Amount, percent	Properties: Weight (1,000 sq. ft.), lb.	Properties: Thickness, mils	Properties: Density, gm. per cc.	Properties: Tensile strength, lbs. per in of width: Machine direction	Properties: Tensile strength, lbs. per in of width: Cross-machine direction
3551	Northern softwood sulfate	Saturating[1]	20	61.7	17.0	0.70	95.2	59.0
4011	do	Beater dispersible	20	70.0	18.0	.75	160.5	88.1
[2]4012	do	do	20	66.9	16.7	.77	117.5	71.0
4013	Spruce steam cooked	do	10	73.7	23.0	.61	56.3	44.8
4016	Northern softwood sulfate	do	20	55.6	14.2	.75	149.5	73.7
[3]4389	do	do	20	53.9	13.9	.72	132.0	67.0
4429	do	do	20	65.2	19.8	.63	100.0	74.8
4456	do	do	20	68.8	17.1	.77	167.0	91.3
4457	do	do	20	91.1	22.4	.78	190.6	120.3
4732	do	do	20	69.8	17.6	.76	167.0	87.0
4390	Aspen neutral sulfite semichemical	do	20	72.9	18.4	.64	149.0	91.0

[1]Treated on an impregnator in an off-machine application with a water-soluble type. Propeties given are for the paper before treatment.
[2]0.5 percent wax size added to pulp finish.
[3]Paper coated on one side with carboxymethylcellulose (0.5 pound per 1,000 square feet).

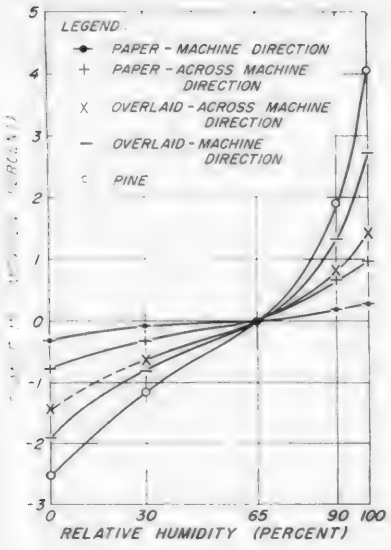


Fig. 1.—Dimensional characteristics of resin-impregnated overlay sheets 0.018-inch thick, ponderosa pine lumber 25/32-inch thick, and the overlaid pine lumber.

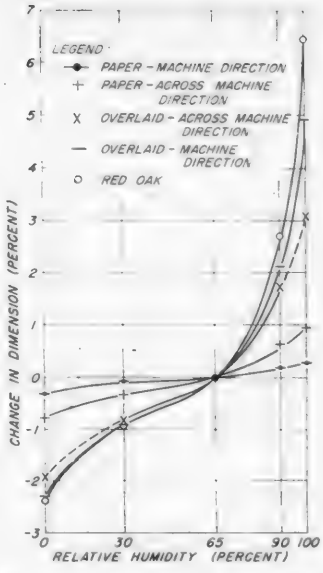


Fig. 2.—Dimensional characteristics of resin-impregnated overlay sheets 0.018-inch thick, red oak lumber 23/32-inch thick, and the overlaid red oak lumber.

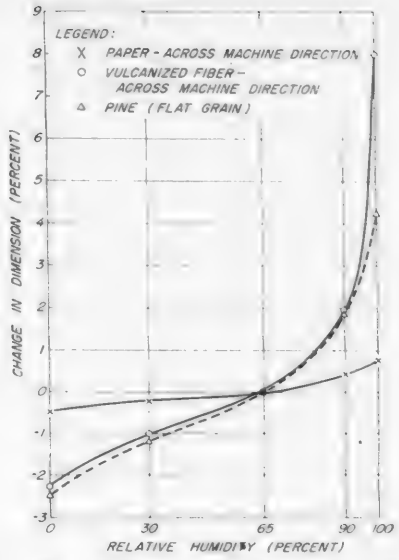


Fig. 3.—Dimensional characteristics of resin-impregnated kraft and vulcanized fiber overlay sheets compared to flat-grain ponderosa pine boards.

alone, depending in part upon whether the machine direction of the paper is parallel to the lumber grain or at right angles to it (4).

In the parallel orientation, the movement of the composite is greater and the stresses are lower than when the machine direction of the paper is at right angles to the grain direction of the lumber. The dotted lines on Figure 1 and 2 indicate conditions which normally cause failure of the overlay paper because of the stresses. When the two materials were cross-laminated, the overlaid pine failed to dry below 30 percent relative humidity. The cross-laminated oak failed below 30 percent relative humidity and above 90 percent relative humidity. Inasmuch as cross-laminating the two materials requires paper as wide as the length of the boards, most of the overlaid material in this study was parallel laminated. Figure 1 indicates that parallel laminated. Figure 1 indicates that parallel-laminated overlaid ponderosa pine approximately ¾ inch thick would shrink and swell about one-third less than similar material without the overlays. The reduction in shrinking and swelling of overlaid oak is considerably less than that of the overlaid pine because of the greater stresses exerted by the higher-density wood. Other tests have shown that the dimensional movement of thin overlaid lumber is less than that of similarly overlaid thick lumber, again because of the reduction in stresses.

Partial stabilization which results from resin-impregnated kraft sheets glued to each side of a piece of lumber is a definite advantage for many products, such as facia boards, shelving, and cabinet interiors. Other products, however, may require the upgrading or masking on only one surface or are of wedge-shaped cross sections (such as bevel siding), which makes overlaying on both sides unnecessary or difficult. If the resin-impregnated kraft overlay sheet is omitted from one side, cupping results from the unbalanced construction. If, however, the overlay sheet had the same unrestrained dimensional movement characteristics as a typical flat-grain board, it should be possible to bond the two together (with the machine direction of the overlay sheet parallel to the grain direction of the board) to produce a relatively stress-free composite that should cup no more than the board without the overlay.

In 1955, the unrestrained dimensional movement characteristics of many sheet materials possibly suitable for one-side overlays were measured at the Forest Products Laboratory. Vulcanized fiber had the required characteristic. "Vulcanized fiber" is unsized, unloaded paper that has been run through a bath of zinc chloride solution and then washed until wash water analysis fails to show zinc. One type of vulcanized fiber, a 0.005-inch thick sheet made from rag furnish, had dimensional movements of about 10 percent across the machine direction from ovendry to soak condition (Figure 3). This movement is slightly more than that of most woods in the tangential direction. It was thought that the slight restraint from the glue line (between the fiber sheet and the wood) might cause additional restraint which would result in a balanced construction.

Subsequent tests showed this supposition to be essentially correct. Figure 4 compares the difference in the degree of cupping between flat-grain southern pine boards overlaid on both sides with resin-impregnated kraft and those overlaid with vulcanized fiber. The boards later were resawn diagonally to make two pieces of bevel siding. The sections shown in Figure 4 were photographed while in a rather dry condition. If the sections are reconditioned to a moisture content of 12 to 15 percent (approximately that at which they were fabricated), the pieces overlaid with vulcanized fiber will remain flat, and those overlaid with resin-impregnated paper again will become nearly flat. If the sections are brought to a high moisture content, those overlaid with resin-impregnated paper will cup in the opposite direction from that shown, and those overlaid with vulcanized fiber again will remain almost flat.

Patent Application Serial No. 652317 was filed April 11, 1957. The basis for this patent application was the use of a relatively thin fiber sheet glued to a wood surface for purposes of upgrading the surface by covering objectionable defects. The dimensional properties of the fiber sheet (across the machine direction) are almost identical to those of the wood to which it is to be bonded; this result's, therefore, in an essentially stress-free construction when the fiber is applied to one side of the wood only.

In spite of adequate proof that this specific orientation of machine direction of fiber sheet and grain of lumber was important and produced the results anticipated, and that all of the patents cited by the patent office failed to

Fig. 4.—Cupping in southern pine bevel siding overlaid on one side only with resin-impregnated paper as compared to similar siding overlaid with vulcanized fiber.

reveal this conception, the patent application was rejected and abandoned in January, 1960. Inasmuch as the Forest Products Laboratory was forced to abandon this application, it would appear that the use of vulcanized fiber on one side of a piece of wood for purposes of upgrading the surface without producing severe cupping is unpatentable over prior art.

Specific Research Studies and Weathering Exposures

Test Fence Siding Exposure at Madison: During the summer of 1952, the Forest Products Laboratory prepared about 100 square feet of wide overlaid lumber siding similar in pattern to edge-grain redwood siding 12 inches wide. In September 1952, this material was exposed on both sides of a standard section of the Laboratory's exposure fence at Madison, Wis., along with a similar panel of high-grade edge-grain redwood siding and a panel of No. 2 pine boards. Each panel was divided vertically at the center; one-half was painted with three coats of white lead house paint and the other half with a typical titanium-lead primer and two top coats of a titanium-lead-zinc paint.

During application of the primer coat for each type of paint, a brush-dragging tendency occured as a result of rapid absorption of the oil into the resin-impregnated paper. This tendency was not evident in the application of the second coat of either type of paint.

After 2 years of exposure, there were no visible defects in the base material of the overlaid siding. No apparent difference was observed between the painted surfaces of the redwood and the overlaid pine. The pine panel without the overlay, however, needed repainting to hide the defects.

In September, 1957 (5 years' exposure), the panels were re-examined and found in good condition, with the exception of the previously-noted panel without overlays. At this time they were all repainted. Again, the overlaid lumber panel, particularly the south exposure, was somewhat difficult to paint because of a tendency for the brush to drag.

The next and most recent inspection was made in the fall of 1959 (7 years' exposure). Again, no difference was found in the appearance between the overlaid low-quality lumber and the high-quality edge-grain redwood siding; however, the pine panel without overlays again showed the knots and needed repainting. A composite photograph of the south exposure of the pine panel, as it would appear without the application of overlays, is shown in Figure 5. A careful examination of the painted overlaid panel, particularly over the covered defects, such as knots and checks, revealed no evidence of failure of the overlays after the 7 years' exposure. One particularly bad knot, which is easy to locate because of its proximity to the number 5, is included in the area shown in Figure 6. There was no evidence of failure or distortion of the paper over the area of this knot (shown immediately to the left of the stamped number 5).

A few surplus pieces of redwood and overlaid pine siding from this test fence were installed on a west wall of one of the annex buildings at the Forest Products Laboratory and painted with a typical tinted white lead house paint that had been used on the building. About 2 years after installation, this test area was exposed to a severe hail storm accompanied by a strong west wind. Shortly thereafter, typical hail damage was observed on the redwood siding and was accompanied by surface discoloration at the points of impact produced by disposition of the water-soluble extractives from the redwood. No evidence of damage was noted on the overlaid pine siding.

Overlaid Siding on Forest Products Laboratory Annex Building (7): In the summer of 1953, similar siding material was prepared, but the type and composition of the overlay sheets were varied. This material was installed on the east side of an addition to one of the annex buildings at the Forest Products Laboratory (Figure 7) in November, 1953, and was exposed throughout the winter without paint. In the spring of 1954, it was still in excellent condition and was painted with two coats of tinted white lead house paint. This siding was examined periodically for any variation in the performance of the different types of overlay sheets.

After 3 years of exposure, a few minute checks were observed over some of the rather large sound knots. Since little care was taken to match the

Fig. 5.—Pine panel as it would appear without the application of overlays or paint.

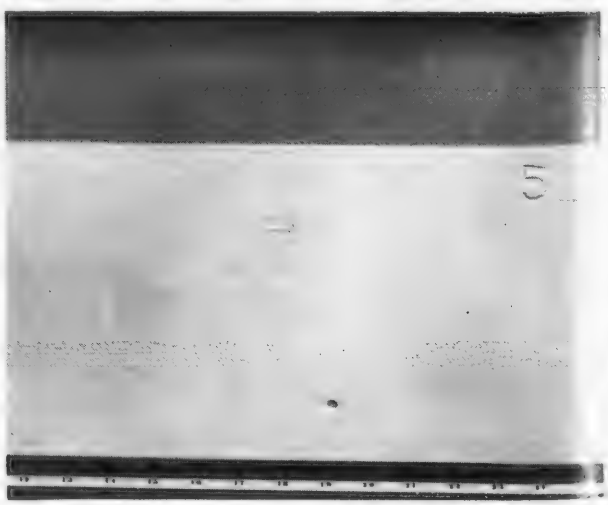


Fig. 6.—The area on the overlaid pine panel immediately to the left of No. 5. Note that the large knot in Fig. 5 (left of No. 5) does not show after 7 years' exposure.

knots with respect to the variations in the paper overlay, no conclusions could be drawn as to the performance of the various overlay sheets. Repainting of this wall in the summer of 1960 almost completely concealed these breaks in the overlay sheet, and no delamination was associated with any of the surface checks.

Miscellaneous Uses of Overlaid Lumber on a House: Additional overlaid material approximately 2 feet wide and 8 feet long was fabricated with a commercial medium density overlay sheet that is used normally on plywood (see lead photo). Some panels were fabricated with a room-temperature setting phenol-resin glue suitable for exterior exposure and others with a typical room-temperature setting urea-resin adhesive.

Several strips about 5 inches wide were ripped from these panels and installed as facia in October, 1954, on the southwest side of a new house in the Madison area, where they were exposed to severe moisture and weather conditions. Boards approximately 12 inches wide were used as shelving in the same house. In both of these applications, the boards were subjected to normal machining operations; no difficulty was experienced in sawing, jointing, mitering, or nailing.

After 5 years of service on this house, the overlaid material was carefully examined and all interior applications were found to be in excellent condition. The facia boards were, for the most part, also in excellent condition except for need of repainting; however, one of the facia boards was partially delaminated. This board was identified as that from the urea-resin-bonded overlaid panel. Those facia boards that gave acceptable performance were bonded with phenolic-type adhesives.

Overlaid Oak and Hickory: In 1954, a quantity of low-quality hickory and red oak was overlaid with one resin-impregnated paper (the standard paper previously described) and evaluated through weathering and cyclic exposure in the Laboratory. The core material was fabricated at two moisture content levels, 6 percent and 12 percent, and in two thicknesses, 3/8 inch and approximately 3/4 inch. Considerable exploratory work on resin-impregnated papers was done, aimed at developing a paper that would perform better on dense wood, such as oak and hickory, than the standard paper. These exploratory tests indicated that only minor improvement resulted from thicker paper, and no improvement took place by strengthening the paper in compression. Therefore, the standard paper was used in the evaluation tests of the overlaid oak and hickory.

The 4-foot-long weathering specimens (in the two thicknesses) showed considerable end-checking after 5 years of exposure and, although there were no controls without paper (which might have end-checked more frequently or deeper), this performance was considered unsatisfactory. Furthermore, the knots and plugged knotholes were poorly masked after the exposure. There appeared to be no difference between the material fabricated at 6 and at 12 percent moisture content, or between the performance of the 3/8-inch and 3/4-inch thicknesses. The performance of the oak was only slightly better than that of the hickory, but both are considered unsatisfactory because of warping and end-checking.

To illustrate two potential uses for overlaid oak and hickory boards, a small building, similar to a tool shed, was sided with horizontal and vertical (board and batten) siding of overlaid oak and hickory lumber in 1956 at Athens, Ga. Some siding of both types was painted and some was left unpainted. The condition of one side of this building (the horizontal lap siding) by July, 1960, is shown in Figure 10. The painted areas of the overlaid lumber siding are in excellent condition and show no signs of paint failure after about 4 years. The unpainted areas are somewhat discolored and exhibit a tendency to end-check (Figure 8).

Fig. 7.—Overlaid pine siding installed on an annex building at the Laboratory in November, 1953, was not painted until spring, 1954. Repainting in 1960 concealed minute surface checks.

Fig. 8.—Overlaid oak and hickory horizontal siding on a building at Athen, Ga., after about 4 years' exposure.

Overlaid Aspen and Cottonwood: Aspen and cottonwood as a base for overlaid lumber were investigated late in 1955. Edge-glued aspen and cottonwood boards containing typical sound defects were overlaid on both sides with the standard resin-impregnated paper to evaluate the effect of exposure to the weather for one year and the effect of typical cyclic interior exposures. Variables, such as painted versus unpainted material, 6 percent versus 12 percent moisture content at the time of fabrication, and 3/8 inch as compared to 3/4 inch thickness were included. An additional objective of the

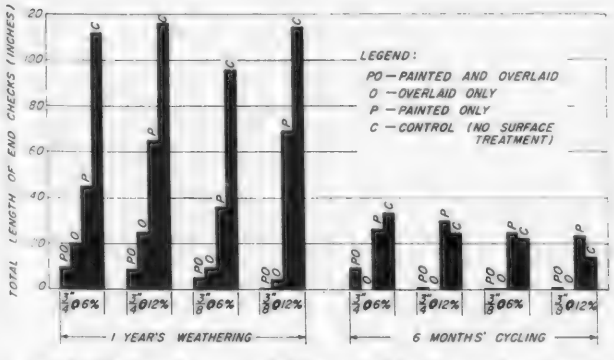

TOTAL LENGTH OF END CHECKS (INCHES)
LEGEND:
PO — PAINTED AND OVERLAID
O — OVERLAID ONLY
P — PAINTED ONLY
C — CONTROL (NO SURFACE TREATMENT)
1 YEAR'S WEATHERING
6 MONTHS' CYCLING

Fig. 9.—Bar chart presenting th amount of end-checking produced in overlaid aspen and controls resulting from 1 year of weathering and 6 months of alternate cycling.

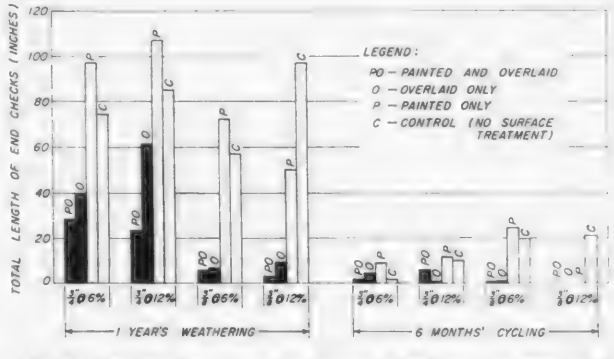

TOTAL LENGTH OF END CHECKS (INCHES)
LEGEND:
PO — PAINTED AND OVERLAID
O — OVERLAID ONLY
P — PAINTED ONLY
C — CONTROL (NO SURFACE TREATMENT)
1 YEAR'S WEATHERING
6 MONTHS' CYCLING

Fig. 9.—Bar chart presenting the amount of end-checking produced in in overlaid cottonwood and controls resulting from 1 year of weathering and 6 months of alternate cycling.

Fig. 11.—Typical stacks of overlaid aspen and aspen control panels without overlays after the cyclic exposure.

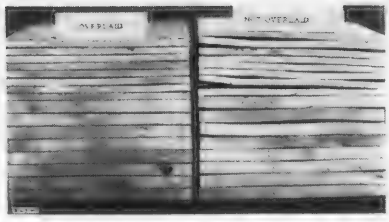


Fig. 12.—Typical stacks of overlaid cottonwood and cottonwood control panels without overlays after the cyclic exposure.

work was to determine the reduction in shrinking and swelling across the grain caused by gluing the resin-impregnated overlay sheets to each side. The adhesive between the overlay sheets and the lumber core was a typical acid-catalyzed phenol resin that set at room temperature.

The amount of end-checking that resulted from one year of weathering and 6 months of alternate cycling (a month at 30 percent followed by a month at 90 percent relative humidity) is shown in Figure 9 for aspen and Figure 10 for cottonwood. The slight improvement in flatness because of overlaying is shown in Figure 11 for aspen and Figure 12 for cottonwood. The improvement in dimensional stability across the board because of overlaying ½-inch-thick aspen and cottonwood is shown in Figure 13 and 14. The overall dimensional movement, from ovendry condition to soaked, is about one-third less for the overlaid material than for the material without the overlay.

A typical group of aspen test specimens ⅜ inch thick after weathering for 3 years is shown in Figure 15. This photograph shows evidence of better paint performance on the overlaid material than on the matched panels without an overlay.

Stadium Seat Planks at University of Wisconsin (6): Early in the summer of 1954, a variety of variables of overlaid 2-inch by 12-inch planks were prepared and installed in 12 rows (192 seats) on the east side of Camp Randall Stadium on the 50-yard line. The purpose of this work was to determine whether overlaying low-quality planks would produce a satisfactory stadium seat that could be exposed for a long period unpainted and with little or no slivering, a common fault with unprotected wood plank seating.

Several variables were included:

Douglas-fir at 12 percent moisture content and Ponderosa pine at 12 percent moisture content were the species overlaid.

The overlays for one or both sides were 4 plies of 0.017-inch masking paper, 0.030-inch high-resin backing sheet, 0.050-inch high-resin backing sheet, or ⅛-inch wet-formed tempered hardboard. Water repellency treatment, renewed yearly and water repellency treatment with the original application only were used as well as no treatment at all in the category of treatments. The controls used were clear redwood, edge grain; and clear Douglas-fir, flat grain.

The planks overlaid with hardboard were glued with an acid-catalyzed phenol adhesive, that sets at room temperature, in a cold press at 150 pounds per square inch for a period of at least 4 hours. The resin backing sheets were glued to the planks with a room-temperature-setting resorcinol adhesive.

The masking-type paper overlays of low resin content were prepared by treating kraft paper of 0.017-inch thickness (MR 3351) with about 20 percent of water-soluble phenolic resin in an experimental impregnator. The resin was diluted with a 50:50 mixture of water and ethyl alcohol to give the desired concentration and good penetration of the paper. The temperature of the drying tower was about 140° C. at the center, and the speed of the sheet through the 12-foot tower was 2.5 feet per minute. Under these conditions, the volatile content of the sheet emerging from the tower was 8 to 9 percent. The paper increased from a thickness of 0.017 to 0.0215 inch because of the resin impregnation. The sheets of the paper were exposed for 45 minutes between platens of the hot press with no pressure. The platen temperature was 315° F. After curing, these sheets were glued four plies thick, using an acid-catalyzed phenol adhesive that set at room temperature betwen the individual sheets of paper and between the paper and the wood. The pressing was done in a cold press at 150 pounds per square inch for a period of at least 4 hours.

The base planks were, in most cases, edge glued, and some attention was paid to the orientation of the grain to achieve edge-grain edges as far as possible. A room-temperature-setting resorcinol adhesive was used for this edge-gluing operation. All planks, with the exception of the molded planks (prepared at a commercial plant), were rounded on all edges. The molded planks were made from edge-glued pine planks prepared at the Forest Products Laboratory, which also supplied the adhesive (a room-temperature-setting resorcinol) used in the preparation of these molded planks. In a final inspection of the planks before installation, a few blisters were found in the molded planks. These blistered areas were marked on the bottom of the planks for future reference. The cover photograph shows the installation of the seats.

Periodic inspections of these seats were made at approximately 6-month intervals from October, 1954, to September, 1960. The behavior, in general, of all the combinations has been exceedingly good to date; however certain types have exhibited characteristics worthy of note. The tempered hardboard overlays have become rough and "crummy" with loose particles that are easily rubbed off. The overlay sheets with low resin content have numerous hairlike checks or cracks across the machine direction; however, not serious and not accompanied with delamination. All the overlays have faded considerably, particularly the dark-colored high-resin backing sheets.

No difference has been noted in end-checking or general performance between the material that was treated originally with water repellent and not renewed, and the material that is retreated each year. However, at certain times of the year, the material retreated with water repellent yearly seems to collect more dust and soot.

All backing sheets (typical table-backing sheet material) exhibited a "fish scaling effect" after one year's exposure. This was caused by the weathering of the glassine or fish paper (which is commonly used as a parting liner in making these materials). It is not known whether backing sheets can be made economically without the glassine surface sheet or not.

No difference in cupping was found after 4½ years' exposure between the material overlaid on both sides and that overlaid only on the top side. Figure 16 shows the south end of one of the Douglas-fir control planks (no treatment or overlay) and Figure 17 illustrates a similar plank overlaid on the top side only with a 0.030-inch backing sheet.

Stadium Seat Planks at South Dakota School of Mines and Technology: Eight nominal 2-inch by 12-inch ponderosa pine No. 1 grade dimension planks 12 feet long were kiln dried, cut into 5½-foot lengths, and without further planing, overlaid with resin-impregnated paper. Moisture content of the planks varied from about 12 to 17 percent. The resin in the overlay sheet was fully cured before application to the wood. The paper was bonded to the wood at room temperature using an acid-catalyzed

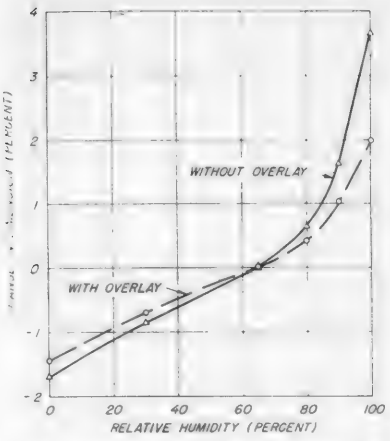
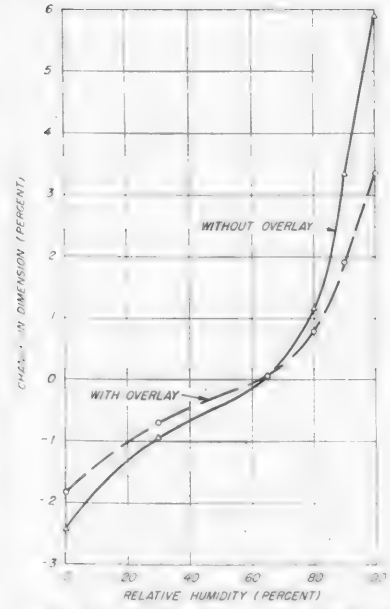


Fig. 13.—Dimensional stability across the grain of overlaid ½-inch-thick aspen and comparable controls with no overlay.

phenolic resin adhesive at a pressure of about 150 pounds per square inch.

Sixteen 5½-inch-long planks were overlaid, 8 on both sides, and 8 on only one side. Fourteen planks were installed in the stadium at the South Dakota School of Mines and Technology, and the remaining two were displayed in a research center office at the Buckingham Wood Products Company, Rapid City, S. D. The paper-overlaid planks were left unpainted but the penta-treated replacement Douglas-fir seats, installed at the same time, were painted. Installation of the overlaid planks was completed in September, 1958.

When last investigated, June, 1960 (one year and 9 months exposure), the paper-overlaid planks showed satisfactory service. The surface was smooth and almost free of checks or other defects. Only a few spots of overlay-separation from the wood surface were found. Weathering, end checking, and cupping have been moderated also. The overlay sheet masked surface defects and prevent surface checking well. Little difference in performance was found between the planks overlaid on both sides and those overlaid on only one side. Moderate cupping and end-checking occurred in both planks. The direction of cupping appeared to be related to the position of the plank in the log rather than to the fact it was overlaid on one or both sides. Furthermore, the amount of end-checking appeared to be related to wood rather than to overlaying characteristics. End-checking started soon after installation and progressed at about the same rate on both kinds of overlaid planks. Little increase in end-checking was found after the first 6 months' exposure. In general, the overlay sheets are weathering slightly, resulting in fading and slight erosion of the surface fibers. A hailstorm caused minor scuffing of the surface; however, this and other weathering has not detracted from the appearance or serviceability of the overlaid planks. According to a statement made by the athletic department, representatives of the school are well satisfied with the performance of these seats.



ig. 14.—Dimensional stability across the g in of overlaid ½-inch-thick cottonwood, c comparable controls with no overlay.

Fig. 15.—Typical group of ⅜-inch-thick aspen test specimen after 3 years' exposure to the weather. Left to right, overlaid and painted, overlaid only, painted only, matched controls.

Overlaid Lumber Siding Demonstration Panel at Carbondale, Ill.: Four panels of paper-overlaid hardwood lumber (overlaid on both sides with resin-impregnated paper) and one of redwood house siding were erected at the Wood Products Pilot Plant, Carbondale, Ill., in July, 1956. The purpose of this installation was to demonstrate the type of work the Forest Service does to develop uses for low-quality hardwoods and to illustrate one of the potential uses for paper-overlaid lumber, exterior house siding.

Seven-foot-square panels were covered with paper-overlaid cottonwood lumber, 21/32 inch thick; paper-overlaid hickory lumber, 21/32 inch thick; paper-overlaid oak lumber, 21/32 inch thick; paper-overlaid oak lumber, ⅜ inch thick; and commercial redwood bevel siding, ¾ inch thick. These materials were in the form of siding about 11½ inches wide.

The paper-overlaid lumber, applied to simulate bevel siding, was nailed with eightpenny corrosion-resistant nails over ½-inch asphalt building board to 2-inch by 4-inch studs spaced 16 inches apart. The overlaid lumber siding was end-matched so that the butt joints were not centered over studs.

One-half of the front side of each panel was painted with a titanium-lead house paint, and the other half was left unpainted.

After 3 years' exposure, the paint on all panels was in excellent condition. Except for numerous splits in the core at the end and butt joints that developed in the overlaid oak and hickory boards, the overlaid lumber under the paint was in good condition. The paper had ruptured over these splits, giving the panels a rather unsightly appearance. Based on this installation, overlaid oak and hickory boards seem unsuitable for exterior house siding.

Overlaid cottonwood boards were in good condition under the paint; however, decay developed at several end and butt joints on the unpainted portion of the panel. It appears that cottonwood and similar soft hardwoods if adequately protected against decay, might be satisfactory for overlaid lumber siding.

Overlaid Southern Pine Siding on Forest Service Building in Brewton, Ala.: Early in June, 1956, approximately 600 board feet of rough, air-dried No. 2 Common southern pine 1-inch by 8-inch boards approximately 8 feet long was used to demonstrate the feasibility and practicability of overlaid rather low-quality lumber for use as vertical and horizontal house siding. Since moisture content of the lumber was from 11 to 14 percent, it was further conditioned in a kiln to obtain a uniform moisture content of 12 percent.

A quantity sufficient for the required 8-inch bevel siding was randomly selected from this shipment and surfaced to the proper thickness so that after resawing, each board would yield two pieces of standard 8-inch bevel siding. About one-quarter of the pieces selected to be resawn for bevel siding were overlaid with vulcanized fiber, 0.005 inch thick. Approximately one-half of the bevel siding was overlaid with resin-impregnated overlay sheets (M. R. 4722 or 4456—two machine runs of the same paper). This paper was approximately 0.018 inch thick and contained about 15 to 20 percent of phenolic resin fully cured in the sheet before being glued to the board. About one-eighth of the pieces was overlaid with a thinner resin-impregnated paper (M. R. 4389) which was about 0.012 inch thick. The remaining one-eighth was not overlaid and was intended for controls.

All overlaid material was pressed in a cold press for a minimum period of about 4 hours at a pressure of 200 pounds per square inch. A typical acid-catalyzed phenol adhesive that set at room temperature was used with a normal spread on the wood surface only. After it was resawn, all material was remarkably flat, an indication that there was no stress in the boards and that the moisture content was in approximate equilibrium with the Madison atmosphere at that time of the year.

The remainder of the shipment was cut into shorter lengths and overlaid for later processing into vertical V-groove siding. About 60 percent was overlaid on both sides with the conventional 0.018-inch-thick resin-impregnated paper; about 20 percent was overlaid with the 0.005-inch vulcanized fiber on both sides; and about 20 percent was processed with no overlay (again to serve as controls). The pressing schedule for the vertical siding was the same as that used on the bevel siding.

Early in August, 1956, all this material was shipped to the East Gulf Coast Research Center, Brewton, Ala., for installation on a new combination office and research building. Before the siding was installed on the building, each piece was dipped in a clear paintable water-repellent preservative for added protection against decay, and possibly to retard or eliminate the growth of mildew on the painted surface, particularly on the north side of the building. The controls and the material overlaid with the resin-impregnated paper absorbed the dip treatment normally and were dry to the touch shortly after dipping. The material overlaid with vulcanized fiber, however, had a heavy deposit of oily-waxy material on the vulcanized fiber several days after dipping and was considered unpaintable by the painters on the job. They washed this surface, presumably with turpentine, to remove the oily deposit before the siding was installed on the building. In installing the overlaid siding, the carpenters found that both the resin-impregnated paper-overlaid material and the material overlaid with vulcanized fiber machined, handled, and nailed satisfactorily. Its uniform surface texture was preferable to the flat-grain pattern of the controls; consequently, when they found that there was sufficient material to cover the area specified without using the controls, the controls were not installed interspersed with the overlaid material as had been suggested. There is some conventional vertical V-groove southern pine siding without overlays on the south side of the building; however, it is not matched to the overlaid material and therefore, it does not serve as a suitable control for the experiment.

All wood and overlaid surfaces of the building were painted pastel green with a fungus-resistant commercial white lead and oil house paint, commonly used in the Alabama area. The painters commented favorably on the ease of painting the paper and vulcanized fiber surfaces. None of the resin-impregnated paper overlay sheets in this installation was treated to reduce the "brush dragging."

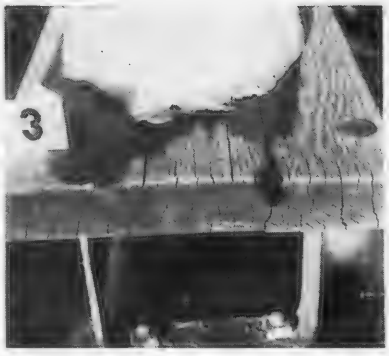


Fig. 16.—Stadium seat plank of Douglas-fir after 4¼ years of exposure. This was a control plank without treatment or overlay.

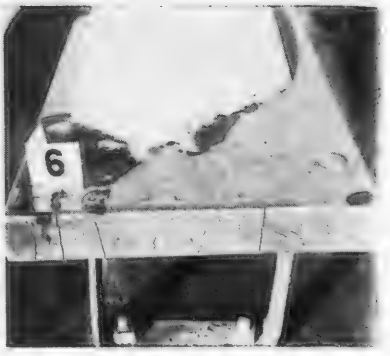


Fig. 17.—South end of an overlaid Douglas-fir stadium seat plank after 4½ years' exposure. A 0.030-inch backing sheet had been applied to the top side only.

Early in the spring of 1960 (about 3½ years after erection), the Brewton building was inspected by personnel of the Forest Products Laboratory. In general the overlaid siding, both bevel and vertical, was in excellent condition with no evidence of checking at the bottoms of the vertical siding, splitting, checking, or cupping of the bevel siding, or of defects (such as knots and pitch pockets) showing through the overlay. The lack of suitable controls on this building prohibits comparison with similar material without overlays.

The V-grooved southern pine tongue and grooved boards, installed both vertically and horizontally on the south side (without overlays), showed considerable evidence of end-checking, particularly of the vertical material near the ground. The overlaid vertical V-grooved material (also on the south side) is in excellent condition. This difference in performance cannot be attributed entirely to the use of overlays as the exposure conditions were different. The overlaid material was installed high on the building underneath a generous overhang and terminated in a brick veneer treatment at the bottom of the window line (about 5 feet above ground level).

The north side of the building, consisting of all overlaid siding with the exception of a small amount of brick, showed considerable evidence of mildew on the painted surfaces. The mildew growth was much worse on the vulcanized fiber overlay than on the resin-impregnated paper overlays. This condition may have been influenced by the removal of the residue from the clear paintable water-repellent preservative treatment that did not dry on the vulcanized fiber and, therefore, resulted in virtually no treatment. This may not be the only cause for the difference in mildew growth. All of the material on the south side of the building was free from mildew growth; however, this side was repainted because of severe fading.

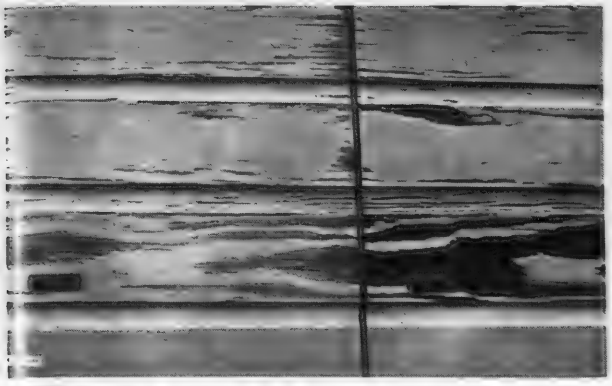


Fig. 18.—Two individual test areas (controls with no overlays) showing typical paint failure on southern yellow pine after 4 years of weathering at Saucier, Miss.

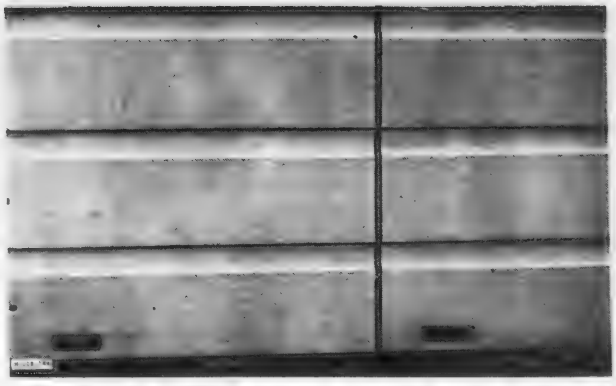


Fig. 19.—Two individual test areas of overlaid siding painted with the same paint shown in Fig. 18 after 4 years' exposure to the weather at Saucier, Miss.

Southern Yellow Pine Exposure Fences in Mississippi and Wisconsin: In 1955, a paint performance study was initiated, intended primarily to observe the performance of a great number of typical house paints on southern yellow pine and to evaluate certain suggested means of improving the paint performance on this problem species. Since the common siding pattern of southern yellow pine is a drop siding (pattern 106), the study was based on this pattern, with use of a limited number of sections of vertical grain, western redcedar bevel siding. About half of the test area of the fence at Saucier, Miss., both north and south sides, was covered with overlaid material. Overlay papers M. R. 4016 and 4389 were used in the study.

It was necessary to overlay the contoured face surface of the drop siding, because the overlays were to be included as a variable in this study. This is not a practical operation, and overlaid drop siding should not be considered as a possible new product. The evaluation of the paint performance on the overlaid material was confined entirely to the flat surfaces, since there was an occasional break of the paper at the point of most severe bending on the pattern.

These test fences were examined after about 4 years of weathering and detailed observations were made on the performance of the various paints, surface treatments, sites, paint integrity, and north-versus-south exposure. The results of this inspection and others to follow will be contained eventually in a report to cover these fences only. Only the effect on paint performance produced by the use of overlays will be reported here.

In general, a marked difference was observed between the performance of the overlaid siding and the matched controls with no overlays. There were differences, naturally, due to paint variables and exposures; but the chronic difficulty was paint peeling over the flat summerwood bands, evident on many of the controls, was entirely lacking on the overlaid material. Figure 18 shows the southern exposure of two individual paint test sections in the control area (with no overlays). The performance of one titanium-lead-zinc commercial paint over a titanium-lead primer, left, and over an aluminum primer, right is shown. Figure 19 shows the same two paint test sections on the panel in which all of the siding was overlaid with the resin-impregnated paper. Both photographs show the same exposure (south at Mississippi) and a comparison of the two shows drastically the improved paint performance on the overlaid material. Not all comparisons between overlaid and non-overlaid were as convincing as this; however, many of them showed the same spotty flaking of paint over the flat-grain southern pine drop siding without overlays, which is typical of paint failures in service when this material is used.

Overlaid Lumber Highway Signs for Texas: Six panels, 2 feet wide and 8 feet long, were overlaid with 0.005-inch-thick gray vulcanized fiber on each side. The usual acid-catalyzed phenolic adhesive at room temperature in a cold press was used for tests made at the Materials and Test Division, Texas Highway Department, Camp Hubbard, Austin, Tex. The cores for these panels were C grade southern pine, edge glued with a resorcinol glue, and planed to a thickness of ¾ inch. The panels were fabricated and shipped to Texas in January, 1958.

A report received from the Highway Department of the State of Texas in January, 1960, stated that the tests made on these signs revealed excellent performance, and they wanted 500 similar panels for further tests. A tentative specification for fabricating these panels was prepared in February, 1960.

Conclusions

To overlay low-quality, sound lumber of any softwood species and the less dense hardwood species of medium-density, resin-impregnated paper or a vulcanized fiber sheet is practicable for such products as house siding, facia boards, stadium seat planks, shelving and cabinet interiors.

The dimensional movement across the grain of nominal 1-inch pine lumber is reduced about 30 percent when it is overlaid on both sides with a suitable resin-impregnated kraft sheet (machine direction parallel to the lumber).

Certain vulcanized fiber sheets can be bonded to only one side of a flat-grain pine board (machine direction of fiber parallel to the grain of lumber) with little or no increase in cupping tendencies.

The paint retention characteristics of flat-grain yellow pine siding are improved remarkably by the use of a paper overlay.

Further work on paper variables seems desirable, especially toward the development of a tougher, more resilient overlay sheet and investigation of other sheets with properties similar to those of vulcanized fiber. However the encouraging results to date on the papers used indicate the advisibility of pilot plant or limited semicommercial production to study the economics of overlaid lumber.

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7. ————, 1956. New process puts good surfaces on poor lumber, House & Home, July.

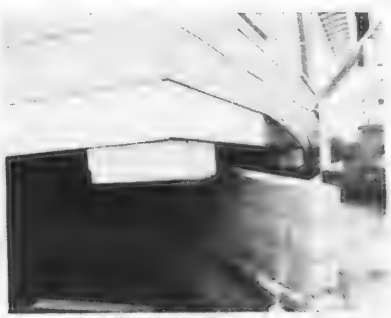
ATLANTIC BEACH HOMES have withstood at least five hurricanes. They prove that well constructed and adequately designed wood homes will withstand the worst that hurricanes can offer.

CONCRETE BLOCK HOUSES did not fare well when hit by water an wind. Roof of this house was carried 2,500 feet. Side walls gav way because of weak tensile strength and lack of ties.

Building Homes to Withstand H

ALTHOUGH MOVED FROM foundation, strength and racking resistance of diagonal wood sheathing kept this house plumb.

WIND ESTIMATED AT 100 miles an hour moved house 15 feet but left it in almost its original condition.



ATTEMPT TO TIE sills of house to the block foundation failed here because the block moved with house.

UNPRECEDENTED DAMAGE, estimated to be more than one billion dollars, was wrought by Hurricane Donna as she moved along a great sweeping 6,000-mile path through the lesser Antilles and the Bahamas, across Florida, along the Atlantic Coast, and over the Northeastern States from Long Island to Maine.

Hurricanes have dealt destruction to the eastern seaboard many times; one commonly expects one or two hurricanes each season. Any coastal area of the eastern seaboard is almost certain of hurricane winds every decade or so, and many areas are staggered even more frequently.

Hurricane Donna completely destroyed 2,814 homes and damaged 52,954 more. Losses estimated right after the storm in North Carolina amounted to more than 31 million dollars to private and public property and 15 million dollars to timber.

Studies of damage following a number of these hurricanes have revealed weaknesses and strengths in different types of building materials and in different methods of construction.

The accompanying photographs give evidence that wood, when properly used, is the best material known for the construction of homes in hurricane and other storm areas.

Based on the evidence shown in these and hundreds of other photo-

The Author: Walton R. Smith is chief of the Division of Forest Utilization Research, Southeastern Forest Experiment Station. He is also Executive Board representative for FPRS Southeast Region.

GOOD METHOD for tying foundation is to bolt sills to notched piling. Note that cross bracing is also bolted.

PROPERLY MADE FOUNDATIONS h e a remarkable ability to withstand damag from wind and water.

Reprints Available. Circle Item 31

A GOOD FOUNDATION on treated timbers, but inadequate ties cost this structure its roof and porch.

A GOOD HOUSE built of wood took the brunt of the hurricane. Entire structure is tied to foundation.

EXCELLENT EXAMPLE of deep, treated piling, good foundation ties, good ties to roof, and wood shingles.

Hurricane Damage

WALTON R. SMITH
Southeastern Forest Experiment Station,
Asheville, North Carolina

graphs taken during case studies made after hurricanes, 10 general rules were drawn up that should assure damage-free homes in severe storm areas:

1. Construct the house on treated wood piling driven at least 10 feet deep. If possible, use the piling as an integral part of the house, and tie it to the roof structure.

2. Use adequate ties between foundation and sills, between sills and superstructure, and between superstructure and roof.

3. Cross-brace the openings between the piling, using cables when possible. Bolt all timber bracing to sills.

4. Use diagonal wood sheathing for increased strength and resistance to racking.

5. Use wood siding or wood shingles for maximum resistance to high winds and flying debris.

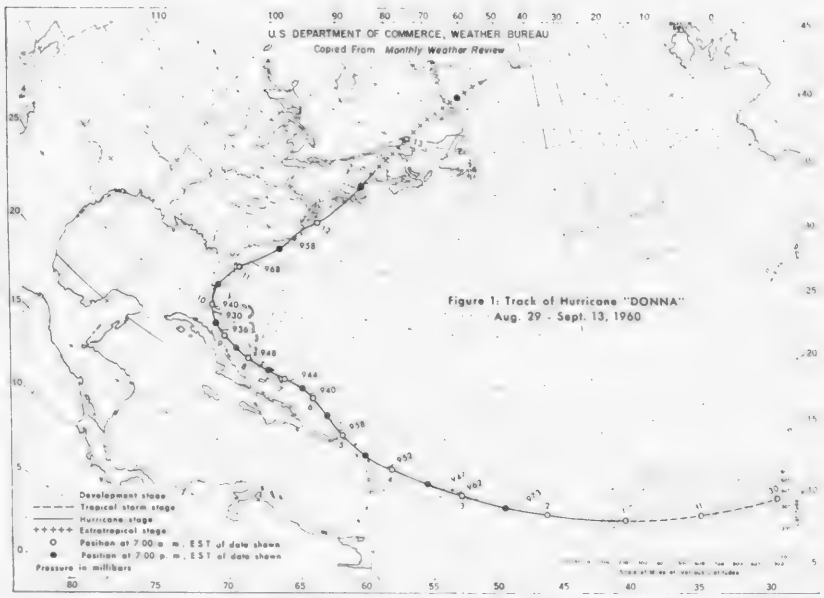
6. Tie porches and roofs to main structure by notching and bolting the structural members. Use steel strapping where direct joining is not feasible.

7. Tie chimneys and other masonry structures to main structural units.

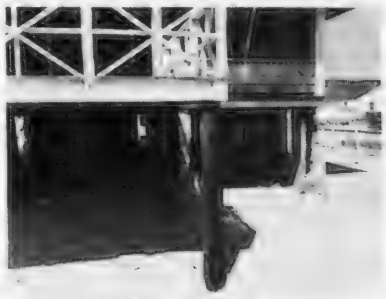
8. Use a wood shingle roof for maximum resistance. If asphalt shingles are used, they should be put down with an adhesive and adequately nailed.

9. Protect all windows and doors with adequate wood shutters.

10. Use wood seawalls on deep-driven piling between house and ocean to diminish wave action.


U.S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
Copied From Monthly Weather Review
Figure 1: Track of Hurricane "DONNA"
Aug. 29 - Sept. 13, 1960
Development stage
Tropical storm stage
Hurricane stage
Extratropical stage
Position at 7:00 a. m. EST of date shown
Position at 7:00 p. m. EST of date shown
Pressure in millibars

HURRICANE DONNA wrought destruction along a sweeping 6,000-mile track through the Lesser Antilles and the Bahamas, across Florida, along the Atlantic Coast, and over the Northeastern States from Long Island to Maine.



TREATED POLES driven 10 to 12 feet saved many homes. Note destruction of concrete block underframing.

DEEP-DRIVEN PILE foundations and bolted cross bracing helped this house take all of Donna's fury.

A condensation of a slide lecture presented at the Southeastern Section Meeting December 1960 in Atlanta, Ga.

Automate Your Lumber Sorting[1]

E. W. DE KONING
Irvington Machine Works, Inc.,
Portland, Oregon

TRAY SORTER at Macmillan and Bloedel, New Westminister, B. C. Operator is positioning lugs that control sorting of lumber into one of 12 trays. (Courtesy Moore Dry Kiln Co.)

LUMBER SORTING is once again being considered and studied by many thoughtful lumber companies, as more ways are sought to meet and beat the ever-increasing labor costs and the inroads being made by competitive materials.

In the past 20 years, we have seen such important improvements as automatic trimmers, dry kilns, automatic lumber stackers and unstackers, log barkers and chippers, and—one of the most recent and widely publicized devices—the automatic set works.

All these improvements have added their share of improved product and production, with a corresponding reduction in manpower. Today, however, all mills still have relatively the same method of sorting and separating the lumber produced by the sawmill. Here is an enormous percentage of the total manpower of any mill. Not only is this segment of the labor force large, but it is generally unskilled and sometimes unreliable.

Many attempts have been and are being made to improve lumber sorting. A fair number of mills, particularly in the south, have spent large sums of money on mechanized edge sorters. Some of these sorters have been very successful; others require about as much manpower to keep them going as was previously required with green-chain pullers, and they consume vast amounts of space. Many mills in the west are now looking to edge sorters or other types of sorters as means of improving the efficiency of their operations. Before they rush into these large expenditures with their questionable results, full consideration must be given to the entire problem.

Think what fantastic numbers of combinations are needed on the green-chain. Width may require up to 7 sorts, while thickness may require 5 or more—plus special cuts. Length generally will require about 10 sorts, again plus special cuts. Add to this probably 7 grades and perhaps as many as 7 species, plus the sorting for drying requirements, such as heart, sap, and heavy sap. Take all these requirements and figure out the possible number of combinations, and there isn't a mill with enough ground space or enough capital to handle the total combinations of sorts that are possible. This is the reason why every phase of the mill operation must be analyzed.

There are four locations in most mills where separation or sorting does or can take place: the log pond or decks, the green-chain, the dry-chain, and the planing mill. Not every mill has the total number of steps mentioned above, or this will affect the number of combinations.

The Ideal System

In the ideal system, species and log grades would be separated in the log pond. Length, thickness, and drying combinations (heart and sap), would be sorted on the green end of the sawmill, and width and grade on the dry-chain. A final sort of length and grade would be made on the planer-chain, where final defects would be removed, and the ultimate in grading would be achieved. This would keep the combinations to a minimum at every location.

Naturally, the size of the mill and the amount of production has a great deal to do with the number of sorts used. A mill producing 50,000 feet may want and could probably use as many sorting combinations as a mill producting 200,000 feet per day. The smaller mill, however, could not afford a capital expenditure of $150,000 to $200,000, while the larger mill could. This is an important point to remember, because the lower the production, the greater the need to combine the various elements.

Lumber Handling

The method of sorting and the combinations used also depends a great deal on how the lumber is to be handled after it has finally arrived in one particular. Place. Will it be air dried or kiln dried? Will it be hand stacked or

The Author: A graduate of Oregon State College, E. W. De Koning is president of the Irvington Machine Works, Inc. He is presently a director in the Woodworking Machinery Manufacturers Association and is on the committee for the 1963 Woodworking Machinery Show.

[1] Presented at the Wood Industries Conference in Portland, Ore., September 10, 1959; revised for publication January 18, 1961.

Reprints Available. Circle Item 32

If your firm is planning to install a lumber sorter, these questions must be answered: How many sorts are needed? What about off-size items? What type of sorter will best fit your needs? Where should it be installed? What are the cost and manpower requirements? . . . Follow this practical approach, and the potential savings can be tremendous.

will it be solid packed and transferred to a stacking chain or stacking machine? How will it be transported—by carrier, fork-life truck, crane, or transfer chains? Fortunately, most mills have already faced this problem because of lack of room on the regular green-chain, and they have put together various combinations that prove as few sorts as they can possibly get by with. Customers also have requirements,, and these do not always include complete and absolute segregation.

Once the number of sorts has been decided, the volume produced to fit into these various sorts must be considered. No mill is going to be able to provide a sort for everything, because there will always be special cuts and off-size items that will require special handling. One of the best ways to handle the relatively small volume of these off-size items is to establish a short green-chain either before or after the sorter-feeding position.

An analysis of production records will show that some of the sorts will accumulate quite slowly. These items could be pulled from the sort green-chain along with the off-size items. It is recognized that such a green-chain would introduce one more man into the operation; however, he will undoubtedly be taken care of 10 or 12 sorts, which normally would have to be added to the sorter at considerable additional expense.

Edge Sorter

There are three basic means of sorting: the edge sorter, the tray-type sorter, and the package sorter. Most people are familiar with the edge sorter, a long continuous line of rolls with a multiple number of slots into which the operator feeds the boards for the necessary length, grade, and width combinations. This type of sorter is perhaps the oldest and most widely used. There are also modern adaptations of the edge sorter where the number of slots are reduced considerably as to thickness and grade only, and the lengths and widths are separated by means of electrical sensing devices.

Edge sorters can be utilized for manual stacking from each sort. Usually, a team of two men move from bay to bay, removing boards from the bin and stacking them either into solid packages or into stickered air- or kiln-dried packages. Further mechanization can provide live bays wherein the lumber is stored until a sufficient quantity is available to make a full package. The operator, by means of an electric foot button, then feeds the live-chain forward, and a board at a time is dropped onto a transfer belt leading to a transfer chain which carries them to an automatic stacker. In such a combination, two men can usually take the place of four or six men hand stacking.

Although the edge sorter is perhaps the most reasonable in cost when used manually, it is perhaps one of the most costly when mechanization is applied. A tremendous quantity of live-chains and associated drives, which must develop high torques, are required, because of the quantity and weight of lumber that must be sorted at one time.

Tray Sorter

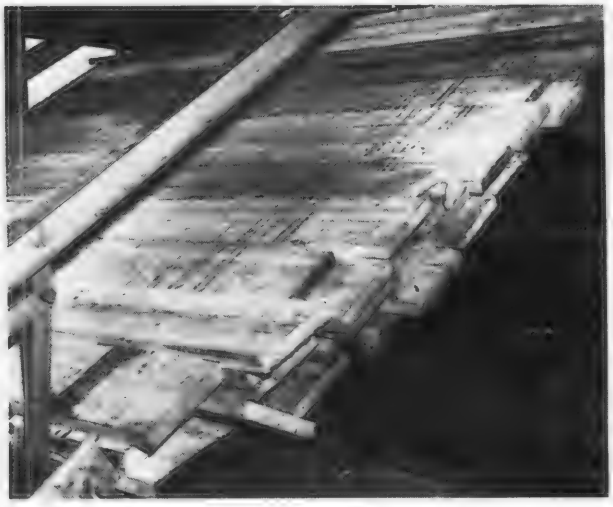
The tray-type sorter consists of a series of trays placed one above the other. The lumber is introduced and carried to the end of the tray, the distance being long enough to accommodate at least a full package. The lumber is conveyed down these trays either by live-chains, or it is set on a decline with skate rolls so that it travels to the end of the tray by gravity. This type of sorter gives extreme versatility, and, unlike the edge sorter, the various trays can be used for different lengths, grades, or widths as production requires. The advantages of this system, however, are offset by high cost of installation, limited number of sorts, and large area requirements. Fifteen trays are usually considered maximum, and mechanical means are the only way in which trays can be fed and discharged.

Package Sorter

The package sorter differs from the others in that the lumber is transferred edgewise and carried on an overhead lug chain. The lumber is fed into and transported by chain-carrier pockets until the board is ejected into the proper bin in accordance with its length, width, thickness, and grade combinations. These bins are constructed to hold at least 1½ stacker loads. When a bin is full, an operator can then feed these boards out onto a transfer chain located under all bins. This transfers the lumber to a stacker located at the end of the chain. The

EDGE SORTER manually operated at R. L. Smith Lumber Co., Mt. Shasta, Calif. (Courtesy Pacific Logger)

STICKERED LOADS being removed from manually operated edge sorter. (Courtesy Pacific Logger)



PACKAGE SORTER with loads in bin before discharge.

PACKAGE SORTER with load discharged to transfer chain.

package sorter provides extreme versatility, and it requires a minimum amount of space, and consequently a lower initial cost. Like the tray sorter, it lends itself to mechanization, but unlike the tray sorter, it is unlimited in the number of sorts that can be made.

Cost Estimates

As a rough rule of thumb, an edge sorter with manual bins, will cost approximately $1,300 to $1,700 per sort. If this same sorter is mechanized with live bays, lumber-transfer belts, and transfer chains to the stacker, a figure of approximately $6,000 to $7,000 per bay can be safely used. This does not include the stacker.

A tray sorter, complete with its mechanized infeeding arrangement, will cost approximately $13,000 per sort. The high cost of the tray sorter is, of course, established by the small number of trays that can be provided, in relation to the structure required.

The bin sorter arranged with its mechanical infeed arrangement, overhead supporting mechanisms, bin storage and transfer chain, but less the stacker can usually be provided for $5,000 to $6,000 per sort.

The manpower requirements for the three basic mechanized type sorters are about the same. Four men are required, one each at the infeed, outfeed, and stacker positions, and one patrolman.

With such a degree of automation, the amount of manpower required on most green-chains can be reduced, and sorting and stacking can be combined into one operation.

When one considers the number of men required on the present green-chain, the equipment needed to remove these packages from the green chain, intermediate storage, transportation to the stacker and stacking, the terrific manpower savings can then be well realized.

BOOK REVIEW

Wahlenberg, W. G.: Loblolly Pine: Its Use, Ecology, Regeneration, Protection, Growth and Management. Published by School of Forestry, Duke University, Durham, N. C., 1960. 603 pp., illus. Price, $7.00.

In this comprehensive treatise, W. G. Wahlenberg has provided a great service for the forest manager and also for the many forest products industries themselves.

Primarily, of course, this book is a monograph containing the essence of all silvicultural facts, practices, and theories on the leading commercial timber species of the southern pines.

In addition to the silvicultural aspect, however, Wahlenberg has devoted much attention to the "how" and "why" of end-product manufacture and utilization of loblolly pine in Chapter 10, "Properties and Uses." Such information is of great importance to the proper management of a tree species with such a broad range of usefulness—"No other wood has a wider range of industrial use." The inclusion of such a valuable chapter on product utilization prompted the preparation of this short review to help bring the book the proper attention it warrants among the industrial members of the Forest Products Research Society.

With clear charts and tables containing data such as conversion ratios for logs to boards from trees of different sizes. Wehlenberg illustrates that profit is sacrificed at small mills that cut more than half their lumber from logs less than 10 inches in diameter. He states that, "Pines under 13 inches should be left standing if sound, or, if defective, should go to a pulpmill rather than a sawmill."

He thoroughly discusses the manufacture, properties, and uses of loblolly pine wood, including such diverse subjects as pulping processes, preservative treatments, seasoning, painting, wood anatomy and structure, dimensional stabilization, strength properties, chemical utilization, log grades, and uses for residues.

The book is technically accurate and detailed throughout, yet is well-written and comprehensive. It deserves a place in the office of any firm that depends on the growth or use of loblolly pine for profit.

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An Operations-Research Approach to Lumber Sorting[1]

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A method of estimating effect of sorting-chain alterations on manpower requirements is presented, with applications in reducing labor or indicating profitable mechanization.

LUMBER SORTING is an important cost in most sawmill operations. In the Pacific Northwest, it is estimated that 15 to 20 percent of mill labor is employed in sorting. This represents an annual wage bill of some $50 million.

There are reasons for expecting that a better understanding of the sorting operation should yield results with profitable applications. The use of manpower on a sorting chain is inefficient because of the variable nature of the work. Mechanization is not necessarily the solution, since automatic sorters require large capital outlays. Moreover, the total sorting operation in a large sawmill is complex. The amount of sorting done at one point affects both the amount of sorting necessary elsewhere and also the use of other equipment, such as kilns and planers.

The operations-research approach analyzes a problem so as to discover the fundamental relationships between the components. In this way, the total system can be understood so that the best combination of factors may be found. This approach is valuable, since proposed changes are often extensive rather than piecemeal. The well-tried methods of trial-and-error and intuition are frequently ineffective in evaluating such changes. Operations research is therefore likely to play an increasingly important part in the forest products industry. Those interested in other applications may refer to articles on optimizing newsprint trim (1),[2] sawmill log-mix (2), veneer assembly (3), logging plans, (4), (5), and a kraft pulp mill recovery system (6).

The Authors: J. Charles Clapham, head of the Operations Research Section, holds degrees from Cambridge and London Universities, England. M. Lambe, an engineer in the Section, holds degrees from the Univ. of British Columbia and from Stanford.

In this paper, the results of observations at a manual sorting-chain are reported first. On the basis of insight into the sorting process obtained by taking these measurements, a "model" of the operation is then constructed. The method of using the model to estimate the manpower requirements of any chain is then given. While this is only one of the factors to be considered in a sorting study, it is one of the most important. The paper concludes with a discussion of other factors involved in the general problem of lumber sorting.

Observations

Observations were made at a green chain of a cedar mill, which is described briefly. Two sets of measurements were taken, one concerned with the manner in which lumber arrived and the other with the way in which the operators handled it.

Description of the Mill: About 100,000 ft. b.m. of cedar per shift was broken down in the main mill and formed the input to the green chain studied. A further 40,000 ft. b.m. was broken down by a sash gang saw and was fed to a second green chain, not included in the study.

The main mill had two band-saw headrigs, a main edger, and a pony edger with a remanufacturing section, which included an edger and a vertical resaw.

Fig. 1 shows the arrangement of loads around the green chain. The chain consisted of two sections in series, each running at a speed of 18 feet per minute. Positions were provided for 86 loads. The chain was manned by 11 operators on each of two shifts, with the operators located approximately as shown in Fig. 1. Besides pulling, operator duties also included the laying of kiln strips between each course of some 60 percent of the loads most frequently used. In this paper, attention is restricted to the operation without stripping, since the main concepts can be explained more easily in this way. Readers interested in the results relating to stripping are referred to a previous research report (7).

Lumber Arrivals: The grade, thickness, width, length, and time of arrival of each piece of lumber were noted for five separate periods of some 10 to 20 minutes. Analysis of this data produced two significant conclusions. First, the arrivals over the short-term were substantially random. When the pattern of intervals between pieces of lumber for the same load was compared with the theoretical expectation for random arrivals, there was an indication of a slight but not important bias towards short intervals. This was probably caused by the production of pairs by a vertical resaw near the output end of the mill. Secondly, over the longer-term there were significant shifts in both the arrival rates and the load patterns. Table 1 illustrates the extent of this variation. The peak arrival rate was about 20 percent higher than the average.

Operator's Method of Working: The operator's method of working may be described with reference to Fig. 2. Each operator had prime responsibility for a group of loads, such as Loads 1 to 5 in the figure. He would normally

[1] Presented at the Pacific Northwest Section Meeting, October 17 and 18, 1960 in Tacoma, Wash.; approved for publication January 12, 1961.

[2] Numbers in parentheses refer to the Literature Cited at the end of this paper.

Table 1.—ARRIVAL RATES DURING FIVE OBSERVATION PERIODS ON ONE SHIFT

Period number	Number of minutes	Average number of pieces per minute
1	6	22
2	10	32
3	14	30
4	20	26
5	22	28
Weekly average		25.8

pull each piece of lumber when it became available opposite its load. The span of the chain for which the lumber could be considered available for pulling is illustrated for Loads 1 and 5. Although it was possible to carry smaller pieces of lumber from outside this span, there was extra time and inconvenience in doing this. It was also possible for lumber to pass to the end of the chain and be transported back to the beginning, but this involved extra cost.

When the operator was not pulling lumber, he would normally proceed upstream searching the chain for lumber for his group of loads. When there was no work for his group of loads

Table 2.—OBSERVED TIMES

Pulling Time	8.0 ± 2.4 secs[1]
Walking Rate	1.5 secs. per 6 ft. load-width[2]
Searching Rate	1.5 secs. per 6 ft. load-width
Chain Speed	18 ft. per minute
Available Time of Lumber	9 ft. = 30 secs.

[1]Standard deviation of 2.4 secs.
[2]6-ft. center to center of loads.

and when he had adequately searched the chain, he would help one of his neighbors.

Table 2 quotes the observed times. The pulling time averaged 6.5 seconds + 0.15 seconds for each ft. b.m. For the mean size piece of 10 ft. b.m., the average pulling time was therefore 8.0 seconds. When walking to reach lumber to pull, the walking rate was 1.5 seconds per load-width (approximately 3 m.p.h.). When walking upstream, searching, the rate was about 3 seconds per load-width. This could be regarded as 1.5 seconds per load-width walking and a further 1.5 seconds searching. The span of chain for which the lumber was judged to be available at its load was about 9 feet, corresponding to 30 seconds at the existing chain speed.

Formulation of Model

The fundamental step in any Operations Research problem is to describe the process being studied by an analytic model. This model can then be used to predict the effect of any change in the system. In our model, the sorting operation is viewed as a queuing process. The pieces of lumber are customers arriving for service; the operators are serving clerks. With a sorting chain of conventional type, the number of men required is determined so that the proportion of pieces waiting longer than the available time is kept to an acceptably low level.

Two methods are available for analyzing a problem of this type. One is the mathematics of Queuing Theory and the other is Simulation. Queuing Theory provides an algebraic solution, thus enabling a large number of hypothetical systems to be assessed very rapidly. To obtain a solution, however, it is necessary to make simplifying assumptions. Simulation, on the other hand, permits a closer correspondence with the real problem. Its disadvantages are that it is time-consuming or costly, and that a separate "custom-made" solution has to be obtained for each sorting system studied.

Both methods were adopted for some hypothetical systems and the results were compared. The agreement was sufficiently good to indicate that the Queuing Theory formulas can be applied to the conditions of many, probably most, sorting chains. Those interested in the details of the simulations and how to perform them should refer to an earlier research report (7). A summary of the Queuing Theory method is presented here in the hope that it will be useful for the preliminary calculations of mill engineers considering sorting-chain reorganizations. The use of more refined methods to allow for points not covered by the theory can be made later if the results appear promising.

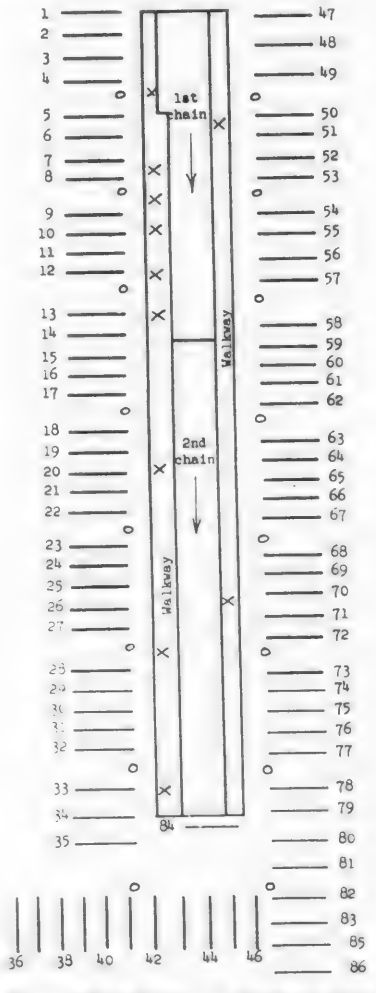

Fig. 1.—Plan diagram of the green chain studied.

Queuing Theory: For the queuing theory solution to be exact, the following assumptions must hold:

a) Arrivals are at random.
b) Pieces are served in order of arrival.
c) Service time (pulling + walking) is the same for each piece.
d) Adequate search is possible during the operator's waiting time.
e) There is no helping.
f) Every piece is served.

None of these assumptions is exactly true, but each is probably approximately true for most chains. The first assumption is the one that may be seriously in error. In particular, the method cannot be used for a chain that serves the direct output of a gang mill.

When the assumptions are made, Queuing Theory can be used to derive a mathematical relationship between three factors:

MAXIMUM DELAY FACTOR, n = the ratio of the available time of the lumber to the service time;
OPERATOR EFFICIENCY FACTOR, r = proportion of time the operator is serving;
and
OVERLOAD FACTOR, T = proportion of pieces waiting longer than the available time.

Since the assumptions are conservative, in the sense that the operator can improve his performance by sometimes serving the pieces out of order or by helping and receiving help, the estimate of T so obtained is an overestimate. It was found that, when the theory predicts $T = 0.05$, in practice negligibly few pieces will have to be taken much beyond their loads. One may therefore take $T = 0.05$ in the Queuing Theory formula and then solve for r for a given n. Table 3 tabulates the values of r corresponding to each n, when $T = 0.05$. On the basis of the operator efficiency, r, and the estimated service time per piece, the manpower required to handle the lumber, can then be calculated.

Estimation of Data for a Particular Chain: Before the formulation of

Table 3 can be applied to any particular chain, the available time, the service time, and the peak arrival rate must be known. Therefore, methods for estimating these are given.

a) *Available time:* According to judgment, the lumber is available for pulling in a span of about 9 feet. The corresponding number of seconds of available time depends upon the chain speed. No exact method of determining chain speed is available, but as a rule-of-thumb (based on observations at chains where the lumber appears satisfactorily spaced), 0.6 feet of chain is allowed per piece of lumber. Below this speed, the lumber appears to pile too deeply, thus increasing the service time. This rule is approximate since the allowance should vary according to the average width of piece coming onto the chain. It should also depend to a lesser extent on the length of chain, since the disadvantage of an initial pile up of lumber at the head may be offset by the advantage of the slower speed increasing the available time for the operators at the foot.

b) *Service time:* The service time, g, of a piece of lumber is the sum of the pulling time, p, and the average time, h, to walk to it. Pulling time can be observed on the chain, or may be determined by the formula:

$p = 6.5$ secs. $+ 0.15$ secs. per ft.b.m.

The walking time, h, depends on the number of loads, N, that the operator has. The average walking distance may be calculated on the basis of random arrivals as:

$(N^2 - 1)/3N$ load-widths.

The corresponding walking time can then be obtained, if the walking rate between load centers is known.

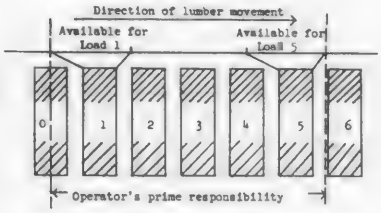

Fig. 2.—Operator load responsibility.

c) *Peak arrival rate:* The manpower on the chain has to be able to handle not only the average rate of arrival of pieces but also the short-term surges. While the average arrival rate is easily obtained from mill records, peak arrival rates will not be so readily available. The peak number of pieces per 15 minutes may be determined by observation at the chain. Empirically, a peak arrival rate of 30 pieces per minute corresponds approximately to 100 M-ft.b.m. per shift. Clearly this cannot be exactly true at all mills since it depends on the average size of piece, the uniformity in the flow of the mill output, and so on. This relationship may be useful for first calculations, however, to assess the effects of system changes.

Table 3.—VALUES[1] OF R FOR GIVEN N (T = 0.05)

n	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1	2	3	4	5
0.						0.094									
1.	0.287	0.309	0.330	0.351	0.371	.391	0.411	0.431	0.451	0.471	2	4	6	8	10
2.	.492	.508	.523	.537	.550						1	3	4	6	7
						.562	.575	.586	.597	.607	1	2	3	4	5
3.	.617	.626	.635	.644	.652						1	2	3	4	4
						.660	.668	.675	.682	.688	1	1	2	3	3
4.	.694	.700	.706	.711	.716	.721	.726	.731	.736	.741	1	1	2	2	3
5.	.745	.750	.754	.758	.762	.766	.770	.774	.777	.780	0	1	1	2	2
6.	.783	.785	.788	.791	.794	.796	.798	.801	.804	.807	0	0	1	1	1
7.	.810														

[1] Read in the same way as a table of logarithms. Example: n = 3.12, r = .628.

Based on formula $1 - T = (1 - r)^n \sum_{i=0}^{k} \exp(n - i\,r)(-1)\,(n - i\,r)^i/i!$ where k is next integer $\leq n$.

Method of Application

To apply the method, one must first establish that the load arrangement around a chain of given speed is unimportant. Hence, given the rate of arrival of lumber to a load, it is possible to determine the proportion of a man's time required to handle it, independent of its location. The method of making such a computation is then outlined.

Effect of Load Arrangement: For the chain studied, the amount of lumber was calculated that two men could handle if one took a few busy loads and the other a larger number of slack ones. The loads were then imagined to be rearranged into two equal groups, each containing some busy loads and some slack ones. The effect of this rearrangement on manpower requirements was never as high as ½ percent over a wide range of examples. It was therefore concluded that the load arrangement around any section of a chain was unimportant.

However, it must be stressed that, where a chain is in more than one section, the load allocation between sections is very important. It can be shown, for example, that if a chain is in two sections with the break in the best location (normally ⅛ to ½ the way down) the least number of men is required when the busy sorts are located on the first chain and the slack sorts on the second. The second chain is then run more slowly since the volume feeding onto it is lower.

Method of Calculating Manpower Requirements: Suppose that a chain layout with the arrangement of loads around it is given. The manpower requirements for each section are calculated separately since the chain speeds (and hence the available time) can differ between sections. The major dilemma to be solved is that, to determine the manpower requirement of a load, the service time has to be known. The walking component of the service time depends on the number of loads the operator has to tend, however. Thus it appears that to determine the men per load, the loads per man must be known. This difficulty cannot be resolved by a straightforward mathematical analysis, but numerical results to particular problems can be found by the use of a chart, as illustrated in Fig. 3. Table 4 shows the steps in the calculation to be made to find the manpower requirements of any load. The results for each load are then added to determine the total number of men.

Discussion

The point has now been reached where it is possible to estimate the manpower requirements of particular sorting-chain layouts. In a sense, no problem has as yet been solved; the process is just beginning. One is now in a position to evaluate different types of layouts. He can examine the possible ways of incorporating automatic sorters into the overall design and evaluate whether the manpower savings justify the expenditure. He can consider whether the increased kiln or planer utilization possible through additional length sorts would justify the extra sorting labor. He can study whether the maximum number of sorts should be made at the green chain or whether more sorts should be left to be made at the dry or planer chain. He can look at the possibility of a recirculating, endless (for example, circular) chain. In short, he has fashioned a tool to use on a wide variety of jobs. How does it work? What changes does it indicate in present practice?

To date the method has not been applied to many specific problems. The sort of general conclusions to which this method may lead, however, may be indicated.

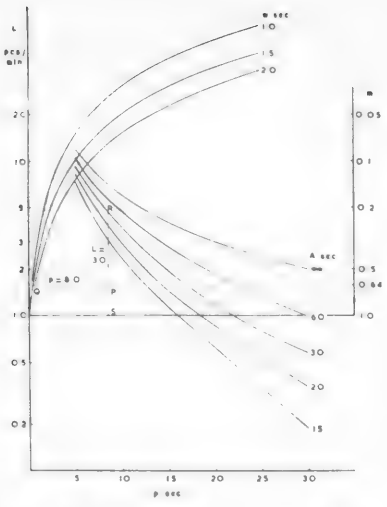

Fig. 3.—Estimation of manpower requirements, to be used with Table 4.

Chain Speed: The first conclusion concerns chain speed. The amount of sorting labor is relatively critical to chain speed. Nevertheless, many sorting-chains are constructed with three or four sections in series and with all the chains running at the same speed. It would apparently be possible to slow the later chains in a series and reduce the labor requirements. At one mill studied, the calculated best chain speeds indicated a saving of one man (out of 11) per shift. The mill management has accepted this conclusion and proposes to make the change together with some others now planned. It should be pointed out, however, that the problem is not as simple as it appears on the surface. First of all, there is in effect some slowing of the chain now since the later chains in a series are allowed to be stopped. If a chain is stopped for 40 percent of its time, a reduction of 40 percent in average speed has been attained. Slowing the chain in this way, however, is an inefficient method. It causes increased bunching of lumber during the stoppage and may leave idle those operators who have no lumber to handle at the time the chain is stopped. Secondly, care has to be taken that the later chains are only slowed as much as the maximum lumber flow will allow. To take an extreme hypothetical case, suppose lumber for the sorts on the second chain averages 50 percent of the mill output, but can account for 100 percent of the output for periods of 15 to 30 minutes. In this case it would not be possible to slow the second chain at all. The obvious change to make here, however, would be to reallocate the loads between sections to obtain a balanced chain with no part of it subjected to prolonged overloads. Slowing of the later chains in a series, therefore, can save labor but cannot be done without considering the load allocation between chain sections.

Automatic Sorters: There is, of course, no fundamental problem in making sorting automatic. The problem is to make it automatic economically. The capital costs of automatic sorters are high and a tray sorter, for example, may cost $12,000 per sort. With investment of this size, it is necessary to have a high utilization. With most lumber sorting systems this is difficult to achieve. The only practicable way of achieving 100 sorts, for example, appears to be by means of 10 primary sorts, each subdivided into 10 secondary sorts. This normally requires considerable storage and handling between the sorts, which introduces the usual problems of inventory.

The most promising application of automatic sorting appears to be with cedar. In a cedar mill, the four busiest sorts may possibly account for some 40 percent of the output. In this situation, it may be justifiable to sort the busiest loads automatically, and the remainder out on a conventional manual chain of significantly slower speed. With a fir or hemlock mill, however, where the four busiest sorts may perhaps account for 10 percent of the output, it is difficult to see how high utilization can be attained. A critical assessment of the total sorting problem is needed before a really satisfactory automatic sorter can be produced. Merely striving to mechanize individual components, such as the green chain, is not likely to be the best method.

Changes in Sorting Procedure on Conventional Chains: Finally, a strong plea should be made for making the best use of existing facilities. While it is always hoped that the ideal automatic sorter will solve the problem, there remains much that can be done to improve the present sorting methods. There are changes that can be made in the pattern of lumber flow, the allocation of loads, the point of break between chain sections, the chain speeds, the number of separately fed chains (perhaps two in parallel rather than in series), and the proportion of pieces which it is desirable to allow to be missed and rehandled amongst others. The greatest improvement in lumber sorting may well lie in this direction.

Table 4.—STEPS IN THE CALCULATION OF MANPOWER REQUIREMENTS

	Example
1. Available Time A	
Let V M-ft.b.m./shift be the input to the chain section.	V = 100
Suppose that 100 M-ft.b.m./shift corresponds to a peak input rate of b pieces/minute. (Suggested b = 30)	b = 30
Suppose chain speed must allow f ft./piece. (Suggested f = 0.6)	f = 0.6
Then chain speed s = fVb/100 ft./minute = 0.18V at suggested values of b, f.	s = 18
Let the available span of the lumber be F ft.	F = 9
Then the available time A = 60F/s seconds.	A = 30
2. Walking Rate w	
Let the rate of walking be w seconds per load-width.	w = 1.5
3. Pulling Time p	
Let the average pulling time be p, either measured directly or estimated from p = 6.5 + 0.15C where C ft.b.m. is the average size of piece.	C = 10 p = 8.0
4. Lumber Volume L	
Let the input of pieces to the load at the peak time be L pieces/minute, either measured directly or estimated from L = Bb/100 where B is average M-ft.b.m./shift of the load.	B = 10 L = 3.0
5. Manpower Requirement m	
Knowing A,w,p,L we may calculate the manpower requirement m by using the chart, Fig. 3. Results for the examples are shown in parentheses in the following description.	
Imagine QPR as a sliding set-square. The corner Q is placed on the appropriate contour of w(1.5). The distance PQ is taken to be equal to p(8.0), as measured on the horizontal scale. The distance PR equals L(3.0) as measured logarithmically on the vertical L-scale. The set square is moved (with the point Q following the selected w-contour) until the vertex R is brought to lie on the appropriate contour of A(30). The distance PS then represents the manpower requirement on the vertical logarithmic m-scale (m = 0.64).	
A transparent template PQRS appropriately calibrated with scales of p,L and m can easily be made to use with the sets of contours of w and A.	

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PERTINENT DEVELOPMENTS IN

Continuous Pulping Systems[1]

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Operating benefits ascribed to continuous pulping are examined. The systems development is related to process changes, changing pattern of pulp usage, and changes in species pulped.

RATIONAL DISCUSSION of systems development in continuous pulping seems necessarily to be in terms of process and equipment, and against a background of present pulping techniques.

Commercial acceptance of groundwood (mechanical) pulp in North America began around 1880, and process equipment developed rapidly. A modern newsprint mill shows impressive automatic and semiautomatic handling and pulp-processing equipment as a result of this development, although the basic pulping action of a block of wood pressed against a rotating grindstone in the presence of water has shown little change, and retains a measure of art in its operation.

Chemical pulping, in which complete fiber separation is obtained by dissolving the basic wood binding agents, began commercially in North America also around 1880, and it too has seen striking development in both process and equipment. With widely different processes, pulping systems development has proceeded fairly independently in the mechanical and chemical divisions.

The fiber-refining equipment that appeared in due course to handle screenings and other coarse fiber common to both divisions has allowed the development of a third division, semichemical pulping, in which the wood binding agents are softened and partly dissolved by chemical action, but a substantial portion of the fiber separation is done mechanically. In recent years there have been a number of variations and gradations in these processes, actual and proposed, with a variety of names, and there is evidence now that the three divisions are slowly moving together.

The properties of pulp fiber as produced are approximately a function of the method of pulping and of species, so that market requirements for the pulp have tended to establish the pulping system in a given mill. Such properties as opacity, brightness, printability, and limited life, which newsprint and many printing papers require, may be obtained from a furnish whose principal component is relatively low-cost mechanical (groundwood) pulp that contains essentially the whole solid substance of the wood. As the binding agents are reduced or removed by chemical action, the proportion of long fibers and the strength of the pulp tend to increase. Some of the other properties may suffer however. The yield, or proportion of the log or chip input that leaves the mill as pulp, lessens as chemical action increases and more fractions of the wood are dissolved. Yield varies from over 90 per cent for mechanical pulps to 40 or 45 percent for some chemical pulps. Yield is an important indicator of pulp properties because it shows what proportion of the original wood substance has been removed, and it has a major effect on pulp cost. Semi-chemical pulp yields, like many of the other semichemical properties, tend to be intermediate between mechanical and chemical pulp values.

Mechanical Pulping Development Has Been Selective

Much development work in groundwood pulping has been directed toward improved block-handling and grinder-feeding methods, and equipment with a great many mechanical improvements. The original handfed single-pocket grinder has been developed to the modern magazine or hopper feed systems, often loaded semiautomatically from a conveyor belt of blocks. Continuity of pulping has thus been achieved to a very real degree without basic changes in the process.

The first major process variation in mechanical pulps was probably the Mason process for hardboard, in which chips were initially defibered by exposing them to steam at high pressures and then allowing them to explode through a restricted orifice by suddenly releasing the pressure. This was and is a batch process, but was followed by the development of continuous equipment for the production of similar fiber without chemical treatment.

The Asplund defibrator provides for delivery of chips from a hopper by a conical-tipped screw feeder, which forms and carries a continuous sealing plug to a steam pressure chamber, usually at 145 to 175 psig. In passage through this chamber, the thermoplastic binding agents are softened, and a second screw feeder takes the chips to an integral rotating disc refiner. As the hot chips pass radially out between the discs, separation into fibers and fiber bundles takes place with an energy consumption approximately 10 to 15 percent of that required for groundwood. Pulp from these units has proved very suitable for hardboards, insulating boards, roofing felts, and similar uses.

Two major refiner manufacturers have reported extensive research programs aimed at producing from chips a mechanical pulp similar in properties and uses and competitive in cost with groundwood pulp. From pilot plant operation it would appear (1)[2] that a pulp with equal or higher mullen and tear values and with brightness and opacity similar to groundwood pulp from the same species can be manufactured with the same order of power consumption as used in grinding. The process employed consists of the continuous delivery of raw chips to a primary stage of disc-refiner fiberizing, and metering of the outfeed to a second stage of disc refining, which is considered to develop strength and control freeness. The refined pulp is then diluted, passed over rotary screens, and cleaned. A special type of screw press has also been used for initial treatment of the chips before refining, but does not now appear necessary. This process is not yet in large-scale use, but it offers some possible interest to the groundwood industry, notably:

a) a chipper will accept much material unsuitable for grinders,

[1] Presented at the Wood Industries Conference, Sept. 10–12, 1959, sponsored jointly by FPRS, ASME, and AIChE in Portland, Ore. Approved copy received for publication Feb. 16, 1960.

[2] Numbers in parentheses refer to the Literature Cited at the end of this paper.

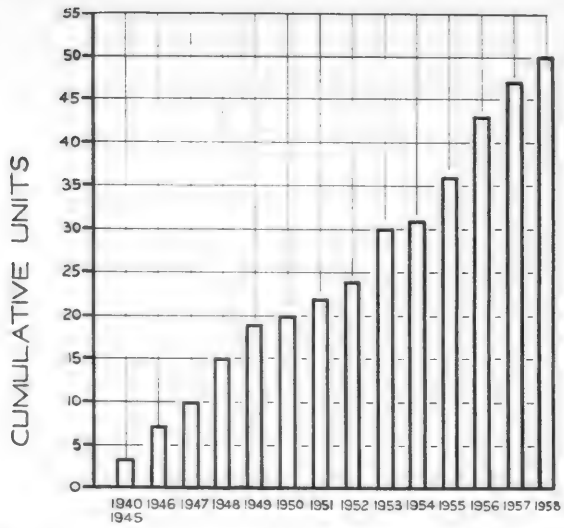

Fig. 1.—Tube-type continuous digesters. North American installations reported by equipment manufacturers.

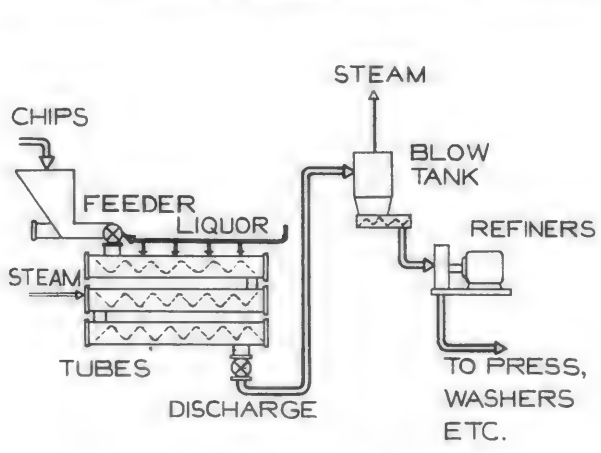

Fig. 2.—Schematic flow diagram of a tube-type digester.

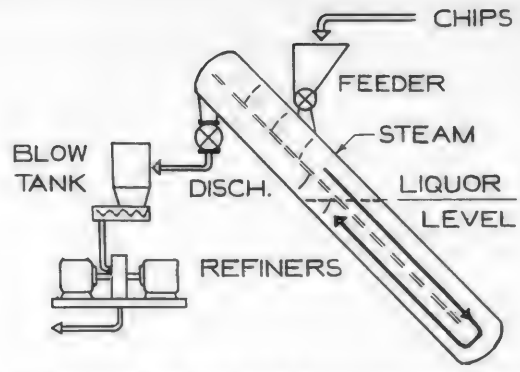

Fig. 3.—Schematic flow diagram of an inclined-cylinder type digester.

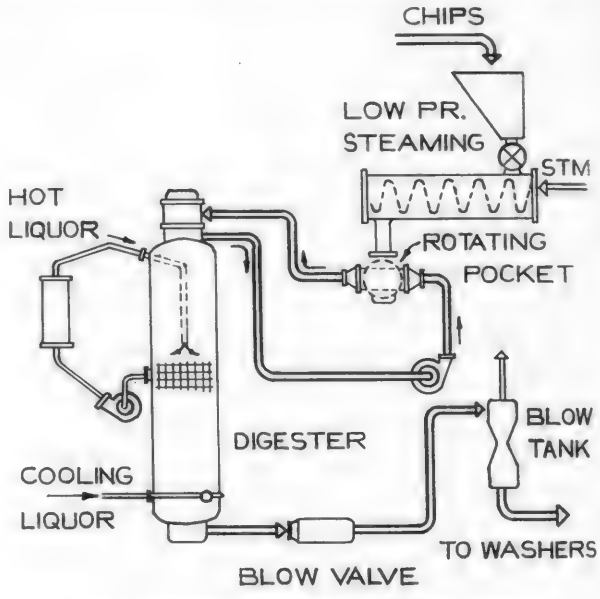

Fig. 4.—Schematic flow diagram of a Kamyr digester.

and some extension of wood supply may be obtained;

b) improved control of moisture content in raw material;

c) chipping and refining are operations better suited to process flow lines, and operating labor requirements are relatively light;

d) space requirements are less than for groundwood, and capital cost savings in new construction appear possible; and

e) it makes readily possible a further step to some chemical treatment of the chips to reduce refining costs.

These considerations would seem to merit examination by the industry.

Four Semi-Chemical Processes Are in Commercial Use

Semi-chemical pulping is frequently associated with the neutral sulfite process, although there are in fact at least three additional processes in commercial use; high-yield sulfite, high-yield sulfate, and cold soda. Neutral sulfite pulping in North America derives from work of the U. S. Forest Products Laboratory in the 1920's, where it was found that useful pulps could be obtained with short chemical retention times followed by mechanical treatment. Yields on the order of 60 to 75 percent resulted. Most applications have been in the pulping of hardwoods, and the pulps have proven particularly useful for corrugating medium, liners, and other high-bulk uses. Recovery of cooking chemicals has frequently been omitted. Original mechanical treatment was with rod mills and various types of refining equipment have been used, but in recent years disc refiners appear to be standard.

After the demonstrated success of neutral sulfite semichemical pulping, high-yield acid sulfite and kraft pulps were produced by following similar methods to neutral sulfite, that is, by decreasing the retention time and completing fiber separation with mechanical refiners. High-yield acid sulfite pulp has found considerable success as an addition to newsprint furnishes, and high-yield kraft pulps are widely used in liners and corrugating medium.

The cold soda process has had recent commercial application, and has been widely reported (2, 4, 5, 6,). Originally, chemical treatment consisted of steeping the chips at atmospheric pressure and temperature for 2 hours or more, but later work showed that liquor penetration could be greatly accelerated by mechanical treatment of the chips (7, 9) and by increasing the hydrostatic pressure in the treating vessel (4, 6). Chemical treatment is followed by a screw press for liquor extraction and initial fiberizing, and then by two stages of disc refining and cleaning. Applications to date have been on hardwoods (aspen, some cottonwoods, birch, soft maple, alder, oaks) although experimental work is widening the list of species and there are indications that pulping of the

finer textured softwoods may be possible. Yields have been reported as high as 92 percent, and pulp properties appear intermediate between those of groundwood and neutral sulfite. In the initial installation, pulp from northern hardwoods is successfully bleached and added to a book-stock paper-machine furnish, replacing groundwood and some bleached kraft.

While batch digesters, frequently rotary, were used initially, the relatively short chemical retention times common to these processes were favorable to the development of continuous digesting systems, and there are many commercial installations. The tube type of continuous digester (Pandia, American Defibrator, Grenco etc.) consists basically (Fig. 2) of a means of introducing chips into a tube or tube system (usually stacked vertically) at elevated pressure and temperature, a screw conveyor system to move the material continuously through the tubes, means of continuously introducing steam and liquor, and a discharge value to return the stock to atmospheric pressure and temperature for liquor extraction, refining, and washing, and which allows relief of non-condensables. This type of unit is well-known to the industry, and may be considered established. (see Fig. 1).

The intake mechanism is necessarily somewhat complex, and has been either a screw feeder (American Defibrator, Pandia) in which a compressed plug of chips forms the seal, or a rotary valve (Grenco, and optional from other suppliers). Steam is usually introduced at or near the chip entry, liquor is entered through a series of nozzles in the upper (impregnating) tube, and total time in the system is usually not over 60 minutes, and may be much less. The tubes normally operate less than completely full, and non-condensables move continuously out the discharge mechanism. Discharge is through a restricted adjustable orifice with small amounts of steam, frequently to a cyclone for separation of gases from the pulp. Recent development work has taken the following forms:

1. Reduction in maintenance cost through improved design, introduction of an automatic stop valve at the screw feeder, and use of more resistant materials, principally around the feeder mechanism.
2. Increase in flexibility and in control of time, temperature, and uniformity of treatment, accomplished through separation of driving elements and better instrumentation.
3. Increased individual sizes, allowing greater throughput or longer retention times, and making process applications more flexible.

There have been two recent continuous digester designs appear in the semi-chemical field. One of these, from the Sprout–Waldron Co., had initial operation in 1957 at Hartsville, S. C., (9) as part of the modernization of an early neutral sulfite mill. It consists of an 8-foot-diameter tube with a continuous vertical divider and four screw conveyors in U-shaped troughs, two above each other on each side of the divider. All four screw conveyors have independent drives, and the two halves may be operated if desired with independent cooking procedures, except only that the pressure be common or nearly so. Operating conditions are similar to the tube units described.

The other recent design, the Medura continuous digester, has some unusual design features. It consists basically (Fig. 3) of a cylinder inclined at an angle of about 45 degrees to the vertical with a compartmented flight conveyor moving on either side of a longitudinal diametrical separator. Chips enter through a rotary valve near the top and are taken by the conveyor the full length of the cylinder and back up on either side of the separator in U-shaped motion to a discharge valve again near the top. Liquor level in the cylinder may be varied, and the construction makes possible successive steaming, impregnating, and vapor-phase cooking in a single vessel with perhaps half the volume of an equivalent batch digester. The manufacturers suggest that only the top of the cylinder need be enclosed and the main body be lagged and allowed to project outside the building and rest on a bottom roller.

The original commercial application of the cold soda process used small, rapid-cycle batch digesters; the second application uses an inclined-cylinder type of continuous digester operating at atmospheric pressure. A pilot plant operating at Berlin, N. H., uses a screw feeder to compress the chips and feed them to an inclined length of enclosed screw conveyor for impregnation and retention. Additional current development work is being directed to introducing liquor as the chips are compressed mechanically in a modification of one of the recent screw-press designs. Continuous change and development may be expected in this recent process.

Continuous Chemical Pulping Development Has Been Slow

Expansion in the chemical pulp industry of North America in the last 25 years has seen a remarkable growth rate of sulfate mill capacity, and development of process equipment has proceeded apace. Individual mill sizes have become very large, and this, combined with a high degree of technical development of batch digesters, has allowed a substantial share of the advantages of continuous cooking to be attained on a batch cycle. The modern sulfate batch digester has become very large and efficient; chip packing, forced circulation, and indirect heating are common, quality of pulp obtained is high, and manpower requirements are relatively low. All of these factors have tended to reduce the pace of development of continuous digestion.

The first North American installation of the Kamyr vertical cylinder type of continuous digester was in 1956. Since then, four additional Kamyr installations are operating, others are in process, and considerable effort is going in to the application to chemical pulping of some of the continuous digesters that have been successful in semi-chemical pulping.

The Kamyr continuous digester for sulfate pulping has been described in the literature (10, 12, 15). It consists basically (Fig. 4), on the infeed side, of a volumetric chip meter, a feeder into a low-pressure steaming vessel with internal conveyor, and a rotating pocket type of high-pressure feeder which allows fluid transport of the steamed chips in cooking liquor to the top of the digester vessel (a 12-foot-diameter by 90-foot-high cylinder for a 300 ton unit), which, with the chip feed line, is maintained under hydrostatic pressure of around 165 psig. The chip column moves slowly downward under gravity to a discharge mechanism in the base of the cylinder, which allows continuous blowing through a length of small-diameter pipe that leads to a small blow tank. There is a vertical temperature gradient in the cylinder ranging from below cooking temperature in the upper impregnating zone through cooking temperature in the upper impregnating zone through cooking temperature in the main length of the cylinder to below 300°F just above the discharge. Primary liquor circulation is obtained by connecting the pressure side of the pump to concentric pipes hung into the digester, and the suction side to peripheral strainer girdles or belts so that liquor flow is radially outwards through the chips. Heaters are inserted on the pressure side of the pump. Cooling at the discharge end is a modification of the original design, and is obtained by entering cooling liquor through peripheral radial nozzles in the bottom section of the cylinder. A further cooling development under study is to enter the cool-

ing liquor through a third concentric pipe so as to displace hot liquor which will be withdrawn radially through a new strainer belt system. In addition to more uniform cooling, this would have the advantages of salvaging the heat in the cook and of getting concentrated black liquor direct to the recovery unit. Time to temperature and time at temperature in general are parallel to batch practice.

There has been limited experience in short-retention-time chemical cooking, and two recent installations, one a tube-type digester for full kraft cooking in a Florida mill, and the other an inclined-cylinder type digester for sulfite pulping in a Minnesota mill, should be informative.

Conditions of timing and chip treatment necessary for satisfactory continuous cooking are the subject of some current discussion. There is now a body of experience available from Kamyr installations which shows that pulp of equal or superior quality to that of batch bleached kraft can be produced from a cycle parallel to that of batch operating, and with minimum mechanical handling of the chips. Minimum cycle times are of course very important to initial capital cost, and will no doubt receive further study as experience accumulates. The superior uniformity and the precision of continuous treatment would appear in themselves to allow substantial gains in time if other variables are undisturbed.

The necessity for extreme avoidance of mechanical handling of chips is a view not shared by all, and in neutral sulfite semi-chemical pulping there is evidence that the mechanical working of chips is beneficial in obtaining faster penetration without pulp degradation. This too will no doubt receive further attention, and the Kamyr research discussed later which relates degradation from mechanical handling to a critical temperature level appears relevant.

Economic Features of Continuous Pulping Are Attractive

To be attractive to industrial management, a major process change will customarily promise or appear to promise one or more of the following:

1. lower capital cost,
2. lower operating cost,
3. widening of raw material base, and
4. improvement in product properties.

Continuous pulping systems have been advocated for many years; there have been numerous installations for certain grades of pulp, and large sums have been expended by equipment manufacturers and by operators. It is apparent that they must offer or appear to offer some of these advantages. These are considered below, mainly in terms of fully chemical pulping with some reference to other processes.

Capital Cost: There is some tendency to look to continuous pulping systems as a possible means of reducing the very large investments that have been reported in recent pulp-mill installations, notably the large sulfate mills in the West and South. Experience to date indicates that capital savings can be made in certain cases, but that such savings tend to have a minor effect on installed mill costs. It has been suggested (10) that the installed cost of conventional batch digester equipment amounts to about 2 percent of the total cost of a modern bleached kraft pulp mill. If this is so, then even if a saving as large as 50 percent could be obtained in equipment (and there is no indication of such a saving at present) it would offset total mill cost by only 1 percent. It may be that the application of continuity in pulping will in time bring about additional economies in other stages of the pulping process, but for the present capital savings can be considered only in terms of a percentage on the replaced batch equipment, including auxiliaries. The savings derive from smaller physical size (much lower in-process inventory), smaller structure required to house the equipment, reduced handling equipment size (maximum feed time rates are much lower), and reduced sizes of auxiliaries (piping, heat recovery, and so forth).

There have been five separate installations of Kamyr continuous chemical pulping equipment in North America in the last three years, with total nominal daily capacity of 1225 tons. From this experience, Kamyr has suggested the following comparative cost estimate for a 300-ton bleached sulfate mill:

Estimated total installed cost of pulping equipment including digesters, auxiliaries, electrical work, piping, structure, instrumentation, etc.	$1,475,000. batch 1,125,000. continuous
Saving	$ 350,000. (23.7%)

This saving includes reductions in structure, chip-handling requirements, and blow heat recovery system. It may be expected to increase with larger installations and to reduce with smaller; a saving of $700,000 has been reported used in the pro forma estimate for a 500-ton mill, and in smaller capacities the saving tends to disappear at sizes around 200 tons. Experience with tube-type continuous digesters for fully chemical installations is limited, but indications are that available savings are of the same order. In semi-chemical pulping, it has been suggested (11) that a saving of $150,000 is realizable with the use of tube-type continuous digesters in a 200-ton neutral sulfite mill. Experience in this field has indicated that capital savings, where obtained, have been associated as much with reduced structure (housing), which of course is a function of a particular installation, as with equipment.

Operating Cost: Experience in other fields has shown that replacement of batch operations by continuous operation generally yields operating savings in labor, in use of materials, and in charges associated with the supply of materials. In any process, the savings possible in changing from batch to continuous operation are very much related to the degree of development and efficiency of the batch system.

Possible labor savings appear large if the mill under consideration operates a large number of relatively small and poorly integrated batch digesters, but if modern large-capacity batch units are in use, these savings are sharply reduced. With modern instrumentation one operator can generally run a continuous digester system up to say 500 tons, although many mill policies would require that a second man be available. If layout is suitable, the second man may look after other adjacent equipment so that his time is normally charged elsewhere. A reasonable approximation might assume modern batch labor at 125 tons per man per 24 hours, or 7.2 man-days for 300 tons as compared with continuous requirements of 3 man-days for 300 tons. Net saving would then approximate 0.1 man-hour per ton of pulp, and would increase to perhaps 0.15 for a 500-ton mill.

In material usage, reductions in total steam demand and in peak steam demand are frequently cited. In a bleached kraft mill, steam requirements might be expected to reduce from 4000 pounds per ton of pulp for batch operation to perhaps 2400 pounds per ton for continuous. The saving here is 1600 pounds per ton, and, depending on the cost and availability of mill steam, might run from $.80 to $1.20 per ton of pulp. Additional savings from removal of demand surges are associated more with piping and boiler installation costs than with operation. There are, of course, a number of integrated installations, in the Northwest particularly, where steam generation is virtually a by-product of the necessary disposal of sawmill waste and has relatively low value. As expansion continues, these are becoming scarcer.

The physical arrangement of continuous pulping equipment will generally permit satisfactory operation with lower liquor to wood ratios than are possible in batch systems where some minimum ratio is required for adequate circulation. It is possible that the handling of smaller volumes of liquor may allow some reduction in usage, but overall the same chemicals are required per pound of cellulose, and reduction in liquor cost can only be expected to come from better uniformity of treatment.

Power demand is, in general, higher with continuous pulping than with batch systems. In chemical pulps, additional power is required in the cylinder-type digester to maintain and circulate liquor continuously under hydraulic pressure, and in the tube type to operate the intake and discharge valving and to convey the chips through the tubes. The amount per ton of pulping varies with the size of the digester. At the 150-ton size, power consumption for the cylinder type is reported at 50 percent over batch, and Kamyr suggests that at sizes in excess of 300 tons overall power consumption is on parity with equivalent batch digesting.

Maintenance costs form a substantial part of total operating costs, and in the present early stage of continuous systems have been reported higher than for batch operation. As equipment design matures, reduction in costs may be expected and maintenance associated with corrosion should normally be less with steady operation as opposed to cyclic operation. In tube-type units, normal life of the screw feeder leading edge has been reported by the Pandia manufacturers and by operators (13) as extended to 2400 to 3000 hours or better, a substantial improvement over early models. Rotary valve feeder maintenance scheduling is apparently of the same order.

Raw Material Usage: Material usage expressed as yield of pulp per ton of chips can, for a particular pulp requirement, be improved by more uniform treatment of individual chips so that the average proportion of components removed chemically is lowered, by obtaining more acceptable fiber from screenings, or by improving certain properties of the pulp so as to make higher yield pulps acceptable to the user. While continuous digesting offers promise of improvement in these directions, there has been no apparent increase in yield in present continuous chemical pulp installations.

Methods of mechanical transfer used in the tube-type and inclined-cylinder-type digesters allow them to handle small-size material with ease and obtain a uniform fiber; they have been notably successful with agricultural residues, and some gain in yield can be obtained through using chip screen fines and shredded waste, the amount depending on the percentage of shorter fiber acceptable in the pulp. It has been pointed out (14) that the strengths of papers are in general a minor fraction of the strengths of individual fibers, and it is probable that the industry is at present wasting much usable fiber because of unrealistic pulp standards.

Pulp Properties Improvement: Improvement in pulp properties may be logically expected through increased uniformity in continuous digesting, and is apparently beginning to be realized. In bleached kraft pulps, the modified Kamyr installations are reporting improved mullen and tear values. In this connection, the research and analysis that led to modification of the blowing system in the Kamyr cylinder appears to be an important advance. In simplified terms, it was found (12) that, when samples of continuously cooked pulp were withdrawn directly from the digester before exposure to mechanical treatment in the discharge system, both mullen and tear values were of the order of 15 percent above usual batch values. By experiment it was found further that much of this increase could be realized by reducing the temperature of the pulp to below 300°F before exposing it to the discharge system. These results should have general application to kraft cooking, but are physically much easier to apply to continuous systems. They would appear to justify research into possible methods of temperature lowering in existing batch systems prior to blowing.

Summary and Comment

1. In sulfate pulping, the Kamyr continuous digesting system in its present stage of development appears to warrant full competitive consideration for projected new capacity, particularly in sizes of 300 tpd and greater. Further applications of the tube type and inclined-cylinder type to chemical pulping may be anticipated.

2. In neutral sulfite semi-chemical pulping, there appear to be both capital and operating incentives to use continuous digester systems in new capacity. The newer equipment coming out will normally be evaluated in terms of the established tube-type units.

3. The most suitable digester systems for cold soda pulping are not clearly defined. Rapid-cycle batch, inclined cylinder, and screw-press impregnating are all being used.

4. It seems reasonable to anticipate the development of disc-refiner pulp as a companion if not direct competitor with groundwood pulp, and that mild chemical treatment will be employed prior to refining. This should be particularly true in regions like the Pacific Northwest and British Columbia, where much available raw material is poorly suited to grinders.

5. The pressure of the large predicted increases in pulp markets must tend in the long run to higher yield pulps through the economic interplay on raw material prices. This will further narrow the present gap between chemical and semi-chemical pulps, and should assist the trend to continuous pulping equipment.

6. Further work in reduction of chip thickness as a means to shorter pulping times may be expected (16). In this connection, the use of thin flakes of controlled sizes in recent particle board manufacture might be considered as a stage of mechanical fiberizing, and offers scope for development.

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Commercialization of Research Results[1]

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PRODUCTS AND MARKETS are changing more rapidly than ever before in the history of the world. The population of this country is exploding and will reach an estimated 200 million in 7 years. Increased consumption of domestic raw materials will force us to draw upon Alaska, Canada, and foreign sources. Peace, security, and perhaps even survival will hinge on the ability to successfully meet these challenges. Other industries may be relied upon to feed, clothe, and provide energy sources for our growing population in the face of dwindling water, lands, and raw materials. Our challenge will be to meet the housing problem which will arise with the millions of new families. This can best be accomplished through successful commercialization of the R & D effort within the building products industry.

R and D

R & D is an infant business grown up overnight. In 1940, about $500 million was spent on research of all kinds and by 1956, the yearly expenditure had increased to $5 billion. Today more than 15,000 companies utilize 500,000 engineers and scientists for research and development. This rapid growth has resulted inevitably in waste —of effort and dollars. Foolproof systems have been proclaimed only to give way to others that worked equally as well, or not at all. Actually, there is no one best method for commercializing research effort. Each concern must study the many and various schemes used by others and select the system best adapted to their company. The author has been in the R & D business for 15 years, and has observed the operation of five distinctly different systems under which products and processes were successfully commercialized. In some cases, however, the transition from an idea to a successful commercial item was less painful than in others. The method we now use is believed to be the best in terms of our experience.

There are no shortcuts to successful commercialization. Here is a step-by-step account of one procedure that has been used. From the idea to the final product, each step is carefully controlled to insure the best interests of the company.

To insure that the product or process is basically sound we believe that it is necessary to go through several steps. There are no shortcuts to successful commercialization.

Our present procedure involves four stages of product and process development, or both. These are:

1) selection,
2) screening,
3) preparation of a business specification, and
4) commercialization.

Selection

Ideas from market research, R & D personnel, domestic and foreign competititve products, management, sales, customers, outside inventors, and friends of the company are sorted for the best interests of the company. It would be foolhardy to evaluate that source which yields the most good ideas. It suffices to say that sound unprejudiced market research, either corporate or hired, is one of the better sources. To insure lack of prejudice, many companies divorce their market research from other company components, and the organization reports directly to a company vice president, or a chief executive. Our market research group is part of our selling organization. A good idea can come from anywhere; hence, it is desirable to keep all pipelines open.

Screening the many ideas is a product planning function and falls to the lot of the product planning manager. He is the key to the success of this system, and he must be a strong, aggressive, and dominant person with a good grasp of company business. He must thoroughly understand the company objectives, raw materials, resources, methods of manufacture, and merchandising. Above all, he must work harmoniously with manufacturing, merchandising, and R & D personnel to sell the merits of sound proposals.

Yardsticks that our product planning function uses in determining the merit of product or process proposals are:

1. Is it in harmony with our policy of maintaining and managing forest lands so as to yield a sustained timber crop of economic value?
2. Does it meet the market needs?
3. Does it best utilize the available raw materials supply?
4. Do we have or can we obtain production know-how?
5. Is it in an area where we have established distribution channels and skills?
6. Is the development and patent position favorable?
7. Are the manufacturing and marketing locations compatible?
8. Is it in a field where the company occupies an advantageous position because of reputation and acceptance?
9. Is it advantageous because of unique personnel skills?

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In screening ideas, the product planning manager often develops proposed ideas; we call this "exploratory" work. Usually, two or three man-days are sufficient to provide a yes-or-no answer. A brief verbal or written explanation from him is considered sufficient to justify selection or rejection of an idea.

Two or three man-days may seem to be a light treatment. However, a constant flow of ideas comes to us despite the lack of a formal "idea" program. Many of these can be quickly discarded since they fail to measure up by one or more of the yardsticks. For example, we are relatively certain that we do not want to manufacture rubber baby pants. Available raw materials would not be utilized, and we have no established distribution channels and skills for selling. Furthermore, it is not a field in which we enjoy reputation and acceptance.

Screening

Selected ideas are screened for those with promise. This is a preliminary analysis in which product, process, markets, and profits are defined. Definition suffices only to establish that the idea is or is not lacking in one of the previously mentioned major areas. If lacking, it is rejected; if not lacking, an intensive study is approved.

Development is primarily responsible for completion of the screening phase, drawing freely upon the requisite business judgement and experience of our manufacturing and merchandising people. This cannot be overemphasized since the commonest fault of R & D people is to rely on business judgement which they rarely have. This can be considered a major cause for ultimate failure to commercialize. Although a man is a recognized expert in the field of nuclear physics, one doesn't expect him to be an authority on manufacturing and merchandising. In fact, it is highly unlikely that he would possess both of these skills. Strangely enough, hard-headed manufacturing and merchandising men may defer to the scientist in awe of his educational qualifications. This problem does not exist in our company. The development man is often and closely questioned in regard to the validity of his various projects. This is, perhaps, the best way to enforce a practical approach to new and improved product and process developments.

In screening, we decide first what raw materials will be used and establish their availability. A preliminary product specification is prepared to insure definition of what we intend to manufacture. Laboratory samples may be made to assist in clarification of the product specification. The potential market is roughly ascertained, and a decision is made on the portion of that market which we might expect to capture. This is done to insure the availability of a volume market. We then estimate approximate unit profit and total profit.

Up to this point in our analysis, we are attempting to obtain a quick yes-or-no answer with a minimum of time and dollar expenditure. If this phase of the investigation is concluded without uncovering serious flaws, we are ready for the preparation of a business specification. Hereafter, a substantial number of dollars may be spent.

Business Specification

The business specification is a full-scale study in which development has primary responsibility. Considered in great detail are:

a) the product use requirements and product specifications,
b) process specifications and plant layout,
c) market analysis, and
d) an operating statement that shows profit potential and return on investment.

Requirements of use must be established to insure that the product adequately fulfills its purpose, thereby providing maximum customer satisfaction. We seem to live in a time in which this important consideration is often forgotten. We build automobiles that hardly can be entered. The fantastically curved windshield distorts rather than improves vision. The seating is uncomfortable, the gas consumption impossibly high. These cars may have "snob appeal" but, because of failure to consider the customers' needs and wants, a sizeable portion of this market is being lost to those who, wisely, meet the use requirements. Many synthetic fiber articles of clothing, certain exterior waterbase paints, and some plastics and metals used in building provide examples of the failure to consider the use requirements prior to marketing. Although intensive advertising may overcome major product deficiencies to an extent and for a limited time, the consumer ultimately seeks those products that most nearly fulfill his needs and at a price he can afford to pay.

When adequate requirements for use have been established, they are used as a basis for the preparation of product specifications. Product specifications must be completed in cooperation with both the marketing and the manufacturing organizations. Sales and development may take an idealized approach, whereas production will want to fix specifications at a minimum level in order to keep manufacturing costs as low as possible. This always leads to some interesting discussions. A tendency exists in some industries today to overdesign a product, to build in unnecessary properties and qualities. This may be prompted by failure to understand the end use, development's desire to astound management with cleverness and originality, or the desire of sales to have something "different" to talk about. Then a decision must be made as to whether to spend manufacturing dollars for these clever but virtually useless features or to spend advertising dollars to sell a technically sound but ordinary product.

After analysis of use requirements and establishment of product specifications, a process specification and plant layout must be prepared. Our wood products development department does this in cooperation with our central engineering department. The extent of the cooperation varies; we seek engineering department advice, and invariably have our final process specifications and plant layout reviewed by central engineering. We believe that it is important to take advantage of the best engineering knowledge available within the company. It is important also since our engineering people make the final working drawings and usually build or contract the construction of the manufacturing facility.

We also draw heavily on the experience of key production personnel in process and plant layout. It is desirable particularly for development personnel to do this since they frequently have no direct production experience or their production experience is out-of-date as a result of several years in development work. Again our aim is to draw upon the best production know-how available to us to insure that those who will operate the production unit have facilities and equipment designed for their needs.

Perhaps the most difficult problem in the field of development supervision is that of stimulating development workers to avail themselves of all the knowledge and skills in product and process design possible. Too many R & D people have read the classic stories of so-called great inventors who accomplished miracles singlehanded. Most of us know that, in many cases, the stories do not represent the facts; however, the image of the secretive genius still persists among many of our people. Most successful inventions, ancient and modern, are the result of a combined effort in which the best thinking of many individuals is forged

into a workable product or process. The ideal development man is a teamworker who can combine the best thinking of research, engineering, production, sales, and consumer into an efficient, economical process to manufacture a satisfactory commercial item. In accomplishing this, the development man must be careful to give credit to those who have contributed or he will "dry up" his sources of information for future developments.

A market analysis may be made by development, or by a market research function. Market analysis is an entity on which enormous amounts have been written. Since it is not the topic for this discussion, it is sufficient to say that we must assure ourselves that our available market, now and in the future, is sufficient to justify the effort. Excellent products have been developed for which there was an insufficient market. We are most interested, however, in products that can be distributed through our normal channels. Our main selling effort is devoted to mixed car shipments to retail lumber dealers. Hence, products adaptable to this distribution system are regarded favorably.

Finally, an operating statement must be prepared to show the profit potential and return on investment. Most companies require that this statement show a potential of 10 to 20 per cent after taxes and a payout time on investment of 2 to 4 years. This statement is prepared in cooperation with our central accounting department to insure that our calculations are made in accordance with standard company procedures and can be understood easily by management personnel. Also, this discourages development people from undue optimism about their "pet" projects, or undue pessimism through fear of being "wrong." A human tendency exists to overlook some of the more intangible and obscure costs. We find that the accountant who must keep the books on each operation is much less likely to overlook any cost items since he deals with them every day. Each product line has costs and expenses peculiar to that product category. Often these are best known to the accounting experts. Again, we avail ourselves of experience within the company.

Although the primary responsibility for preparation of business specifications resides with development, one should note that every effort has been made to consult specialists within the company. It is fatal to assume that development personnel will exercise mature judgement in unfamiliar areas.

The completed business specification is submitted to the product planning manager for final review. If no serious flaws are uncovered prior to or during this final examination, it will be forwarded to the appropriate top management members as a proposal to commercialize.

Commercialization

The period of commercialization extends from the time of approval until the product has been successfully launched. We believe that the manufacturing division is responsible for successful commercialization. The company divisions are divided into branches under the direction of a manager, located where raw materials are available from tree farms. Manufacturing units are located to convert the raw materials. Generally, a branch is selected for erection of a new plant whenever management approves commercialization. The branch manager is responsible for success or failure of any venture at his branch.

Equipment specifications and final working drawings are made by the central engineering department with the responsible manufacturing personnel. The product planning manager serves as liaison between manufacturing and merchandising when marketing plans are being made final. During this stage, development assists only when requested to do so by engineering, manufacturing, sales, or product planning. Ideally, development should work on a new product or process development rather than assist other personnel in commercialization. It is difficult particularly for development personnel to "let go" of a project that is being commercialized. When permitted to do so, development will spend months or years following existing product lines rather than develop new products. Engineering personnel may exhibit the same tendency, assuming long-term responsibility for processes and plants they design. In certain organizations, production does not allow this to happen In others, production may welcome an opportunity to share the responsibility for success or failure. This problem does not exist in our company except as a natural tendency of development personnel to follow existant product lines rather than proceed with new explorations. Neither engineering, development, nor product planning can assume responsibility for successful commercialization of a product or process after top management personnel accept a proposal. This can be fatal, just as divided responsibility and authority are fatal to success of many enterprises. The responsibility for profit must reside with the person who manages the production unit.

Summary

There are many methods for commercialization of R & D results. Our system involves: (1 Selection of ideas; (2 Screening selected ideas for those which offer promise; (3 Preparation of a detailed business specification, including product use requirements, product specifications, process specifications, plant layout, market analysis, and an operating statement. In preparation of this specification, development draws upon the best knowledge available, crossing department or company lines for mutual benefit. (4 Commercialization. After a decision has been made to commercialize, the responsibility for success is assigned to the production personnel who operates the manufacturing unit. A central engineering organization to finalize design and supervise construction may be used and sales drawn upon to define and secure markets. Product planning and development may provide assistance. The primary responsibility for profitable commercialization, however, resides with production.

EVALUATION OF TWO

Bisphenols as Wood-Preservative Agents[1]

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When used as co-toxicants with creosote, copper naphthenate, and creosote-coal tar, two chlorinated bisphenols greatly increased effectiveness of these standard preservatives against terrestrial and marine organisms.

SUBSTITUTED BISPHENOLS have been extensively evaluated as fungicides for mildew-proofing of fabrics and other materials. Among those which have shown a high order of fungitoxicity are 2,2′–methylenebis (4–chlorophenol), frequently referred to as Compound G–4 ® or dichlorophene, and 2,2′–thiobis (4–cholorophenol).[3,4] Compound G–4 was widely used by the Armed Forces during the latter part of World War II as a preservative for textiles and cordage, and is to be found in many U. S. Government specifications.[5]

The problem of protecting wood against biological deterioration is similar to that of protecting fabrics and cordage. In fact, some preservatives, such as pentachlorophenol and copper naphthenate, are commonly used in both applications. In view of the effectiveness of certain of the bisphenols as fabric protectants, it seemed warranted to investigate these materials as wood preservatives. An exploratory evaluation of two bisphenols as wood preservatives was started by Battelle Memorial Institute in 1951 and concluded early in 1960. The results of this investigation, which was supported by the Givaudan Corporation, are reported here.

The two bisphenols included in the present study were Compound G–4 and 2,2′–thiobis (4–chlorophenol) (Compound 30). These materials were evaluated individually in an inert solvent and also in a petroleum solvent, which possesses some wood-preserving properties. In addition, they were evaluated in combination with three well-known preservatives: creosote, pentachlorophenol, and copper naphthenate. The different treatments were applied to stakes of southern yellow pine by a standard pressure-impregnation method. Evaluation of preservative effectiveness was accomplished by exposing the stakes in a soil plot known to be infested with wood-destroying fungi and subterranean termites. The study also included a small series of marine panels impregnated with the same treating solutions, but at higher retention levels than those used for the soil stakes. The panels were evaluated for resistance to marine wood-destroying organisms by exposure in salt water at the Battelle North Florida Research Station, Daytona Beach, Florida.

Materials and Methods

Treating Solutions: Sohio No. 4A Fuel Oil was selected as an inert solvent for the two candidate preservatives and for pentachlorophenol and copper naphthenate. Sohio No. 6 Fuel Oil was used as a diluent for creosote in those treating solutions from which a part of the creosote was omitted and replaced by a smaller percentage of the candidate preservatives. These solvents were then in current use in commercial wood preservation for their respective purposes, according to information from the Koppers Company, Wood Preserving Division, Orrville, Ohio. The No. 4A Fuel Oil was presumed to pass the then-existing American Wood-Preservers' Association (AWPA) Specification No. P9–49, "Standard for Petroleum Used in Pentachlorophenol and Copper Naphthenate Solutions", and the No. 6 Fuel Oil the AWPA Specification P4–49, "Standard for Petroleum For Blending With Creosote". The other solvent used, Panalene SN, was a heavy petroleum oil, over 90 percent aromatic, which had previously been found by trial to possess appreciable wood-preservative activity. It was obtained from Pan American Refining Company, Chemical Products Division, Texas City, Texas.

Copper naphthenate was obtained from Nuodex Products Company, Elizabeth, New Jersey, as a concentrate containing 8.0 percent copper. The pentachlorophenol used was obtained from Dow Chemical Company, and was representative of the grade then being marketed as a wood preservative. The creosote used came from Koppers Company, Wood Preserving Division, Orrville, Ohio. It was identified as meeting the AWPA specifications for Grade 1 creosote.

Table 1 gives the composition of the 14 treating solutions used.

Wood Specimens: The wood for the exposure specimens was carefully selected, air-dried southern yellow pine. Only clear, 100 percent sapwood specimens were used. The specimens were at a moisture content in equilibrium with the laboratory atmosphere at the time of treatment. Moisture was not determined, but is estimated to have been about 8 to 10 percent, on an oven-dry basis. The dimensions of the soil stakes were ¾ by ¾ by 36 inches, and those of the marine panels ¾ by 3 by 18 inches.

Impregnation: The test specimens were pressure-impregnated in a laboratory-scale treating cylinder, which consisted of a section of 6-inch iron pipe, 38½ inches long. The cylinder was fitted with electric immersion and jacket heaters controlled by thermoregulators to maintain the desired tem-

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[1] A contributed paper received June 10, 1960; revised version for publication received December 28, 1960.

[2] The late Dr. R. E. Heiks of Battelle conceived and planned this investigation, and supervised the preparation and early inspections of the specimens. His valuable contribution is gratefully acknowledged. Thanks are also due the Givaudan Corp., Delawanna, N. J., for financial support of the research and permission to publish the results.

[3] Marsh, P. B., and M. L. Butler. 1946. Fungicidal Action of Bisphenols as Mildew Preventives on Cotton Fabric. Ind. Eng. Chem. 38: 701–705.

[4] Marsh, P. B., M. L. Butler, and S. Clark. 1949. Fungicidal Activity of Bisphenols. Ind. Eng. Chem. 41: 2176–2184.

[5] Greathouse, G. A., and C. J. Wessel (Editors). 1954. Deterioration of Materials. 408–506. Reinhold Publishing Corp., New York.

Table 1.—COMPOSITION OF TREATING SOLUTIONS; WEIGHT PERCENT OF INGREDIENTS

	Treating solution													
	A	F	K	B	G	L	C	H	M	D	I	N	E	J
Primary toxicants														
Compound G-4	2.5			2.5			2.5			2.5			2.5	
2,2'-methylene-bis (4-chlorophenol) Compound 30		2.5			2.5			2.5			2.5			2.5
2,2'-thiobis-(4-chlorophenol) Copper naphthenate[1]				12.5	12.5	12.5								
Pentachlorophenol							2.5	2.5	5.0					
Solvents														
Grade 1 creosote	50	50	100											
No. 6 fuel oil	47.5	47.5												
No. 4A fuel oil				85	85	87.5	95	95	95				97.5	97.5
Panalene SN										97.5	97.5	100		

[1] 12.5 percent copper naphthenate (8.0 percent copper) corresponds to 1.0 percent copper in treating solution.

perature during the treating cycle. A pre-charge tank equipped with electric heaters was connected with the cylinder and used for heating the solutions before the pressure cylinder was charged.

The soil stakes were impregnated in this equipment by a standard "empty-cell" process. Thirty soil stakes were treated with each preservative solution, in two runs of 15 stakes each. Operating conditions were varied between the two runs, to give a range of retentions. The marine panels were given a standard "full-cell" treatment to provide the higher preservative retentions characteristically used for marine wood preservation. Six marine panels were treated with each solution. A single run was made for each treatment. The two lowest-retention panels from each treatment were discarded, which reduced the number exposed to four per treatment.

Table 2 gives the ranges of retention values for the soil stakes treated with the different solutions. The table also shows the distribution of the stakes among six retention ranges. Retention data for the marine panels evaluated are given in Table 4, with the results of the marine exposure.

The retentions given represent, in most cases, values determined by weighing immediately after impregnation. In the few instances where bleeding of preservative was noted before exposure, the specimens were reweighed and the retention value corrected. Penetration was not specifically checked on specimens in the present experiment. On the basis of results in similar impregnations made with the same equipment, however, it is believed that penetration was complete for both the soil stakes and the marine panels.

Exposure and Inspections: *Soil Stakes:* The soil stakes were exposed in a plot at the Battelle North Florida Research Station, situated approximately 12 miles south of Daytona Beach, Florida. The area consisted of a sandy soil, which was originally covered with palmetto and scrub oak, and was cleared by hand, with minimum disturbance of the top soil and surface debris. There was ample evidence of the existence of both termites and wood-destroying fungi in the condition of fallen limbs found in the area.

The stakes were driven into the soil to a depth of approximately 20 inches, in rows 18 inches apart with a spacing of approximately 12 inches between stakes. Distribution of the stakes was randomized over the entire plot.

Inspection and grading of the specimens for decay and termite attack was done according to the system recommended by Committee P–6, AWPA.[6]

Decay Grades

1. Sound—no evidence of decay
2. Soft on surface or other possible signs of decay
3. Slight but positive decay
4. Deep or severe decay
5. Failure—almost complete loss of strength

Termite Grades

A. No termite attack*
B. Suspicion of termite attack, not positive
C. Slight but positive termite attack
D. Severe termite attack
E. Failure caused by termites.

When termite grades were averaged in tabulating results, the letter grade was converted to a numerical score: A = 1, B = 2, and so forth.

The 10 lowest-retention stakes of each treatment were removed and graded after 30 months of exposure. After inspection, those stakes with a grade of 3 C or better were replaced in the holes from which they had been removed, and the soil was firmed around them.

A second inspection was made after 50 months of exposure, and the same grading system was used. Inspection was again confined to the lowest-retention stakes in each treatment, but the number of stakes inspected from each group varied, and depended on the condition of the specimens. Where the first stakes removed were in perfect or near-perfect condition, no further removals were made. If the first stakes examined graded low, additional specimens were removed and inspected, until one or two essentially sound stakes had been found. The number of stakes removed varied from 3 to 10, and none of those inspected was replaced.

Between the 50-month inspection and the final inspection, a method of examination was used that did not require removal of the stakes. They were checked periodically for resistance to breakage, by application of a 5-pound bending stress to the top of each stake, alternately from each of the four sides. Under this method of stressing, severely decayed or termite-damaged stakes broke at or near the ground line and were recorded as preservative-treatment failures. Cause of failure (decay or terimite attack) was also recorded. Stakes that appeared to be weak but did not break under stress were recorded as nearly failed, while those which showed no appreciable weakness under stress were judged to be sound. This method has the advantage of permitting periodic estimation of the performance of all the stakes in a series without seriously disturbing the specimens in relation to the exposure environment. [In passing, the author would like to express his belief that this method, which has not to his knowledge been reported elsewhere, offers sufficient advantages to merit further consideration by other workers concerned with stake-plot evaluation of wood preservatives.]

A final complete inspection and grading of all stakes, in accordance with the AWPA grading system described above, was made in January 1960, after 8½ years of exposure. In the interest of brevity, only the results of the 8½-year inspection are reported and discussed below. Results of the 30- and 50-month inspections merely indicated trends, which were substantiated by the results of the final inspection

[6] American Wood-Preservers' Association Proceedings. 1950. Standard Method For Accelerated Tests With ¾ Inch Stakes. 46: 58–61.

* This grade is not included in the published AWPA system, but is inserted here to complete the grading scale.

Table 2.—RETENTION OF PRESERVATIVE SOLUTIONS IN SOIL STAKES

Treatment	Range of preservative retention lb./cu. ft.	Number of stakes in indicated retention range, lb./cu. ft.					
		<3	3–6	6–9	9–12	12–15	>15
A —G-4 in creosote+No. 6 fuel oil	4.1–12.6	0	16	4	4	6	0
F —30 in creosote+No. 6 fuel oil	4.8– 9.2	0	6	20	4	0	0
K —Creosote	4.8–16.5	0	8	16	4	1	1
B —G-4+copper naphthenate in 4A fuel oil	4.4–12.8	0	6	20	3	1	0
G —30+copper naphthenate in 4A fuel oil	4.0–13.4	0	9	6	10	5	0
L —Copper naphthenate in 4A fuel oil	3.7–14.3	0	15	8	1	6	0
C —G-4+pentachlorophenol in 4A fuel oil	4.7–13.3	0	5	18	5	2	0
H —30+pentachlorophenol in 4A fuel oil	2.1–13.8	9	6	1	9	5	0
M —Pentachlorophenol in 4A fuel oil	3.2–10.0	0	15	9	6	0	0
D —G-4 in Panalene SN	4.1–14.3	0	10	12	7	1	0
I —30 in Panalene SN	5.3–10.5[1]	0	2	24	3	0	1[1]
N —Panalene SN	4.3–16.6	0	11	4	4	8	3
E —G-4 in 4A fuel oil	2.9–16.8	1	16	6	2	4	1
J —30 in 4A fuel oil	4.5– 9.6	0	10	16	4	0	0

[1]Except single specimen 22.5.

Table 3.—DECAY AND TERMITE GRADES OF SOIL STAKES AFTER 8½ YEARS OF EXPOSURE[1]

Treatment	Number of stakes[2]	Actual retention range lb./cu. ft.	Average retention lb./cu. ft.	Number of completely sound stakes	Average decay grade	Average termite grade (converted to) number scale)
A —G-4+creosote in No. 6 fuel oil	21	4.3–11.1	6.5	17	1.3	1.0
F —30+creosote in No. 6 fuel oil	27	5.7– 9.2	7.4	15	1.4	1.0
K —Creosote	25	5.6–10.3	7.5	2	2.9	1.2
B —G-4+copper naphthenate in 4A fuel oil	26	5.1–10.4	7.3	18	1.4	1.2
G —30+copper naphthenate in 4A fuel oil	21	5.5–12.0	8.3	7	2.0	1.4
L —Copper naphthenate in 4A fuel oil	20	4.3–10.9	6.1	3	2.6	2.0
C —G-4+pentachlorophenol in 4A fuel oil	25	5.2–11.8	8.0	6	1.6	1.7
H —30+pentachlorophenol in 4A fuel oil	11	4.3–11.9	9.6	5	1.9	1.6
M —Pentachlorophenol in 4A fuel oil	24	4.2–10.0	7.3	1	3.3	2.7
D —G-4 in Panalene SN	25	4.6–11.1	7.9	3	2.0	2.0
I —30 in Panalene SN	26	6.2–10.5	7.5	5	2.2	1.7
N —Panalene SN	16	4.6–11.8	7.2	1	2.9	2.2
E —G-4 in 4A fuel oil	15	4.6–10.8	6.6	0	3.9	2.5
J —30 in 4A fuel oil	25	5.4– 9.6	7.3	0	2.6	3.0

[1]Includes stakes that failed by breakage between the 50-month and 8½ year inspections; these were rated as failures in the final inspection. See text for explanation of test applied during that period. Excludes all stakes that were removed in earlier inspections and not re-exposed.
[2]Falling within the retention range of 4–12 lb./cu. ft.

Marine Panels: The marine panels were evaluated at the exposure dock of the Battelle North Florida Research Station. This exposure site provides a highly destructive marine environment for the testing of wood preservatives. The three major types of marine wood-destroying organisms (shipworms, pholads, and *Limnoria*) are present, and untreated wood specimens are destroyed or riddled within 2 to 4 months throughout the year. The panels were mounted on galvanized iron bars and exposed at a depth of approximately 2 feet below mean low tide level. The panels were cleaned and inspected after 18, 30, and 48 months of exposure. An arbitrary grading scale of 10 (perfect, no borer attack) to 0 (complete failure, panel destroyed) was used in rating the panels.

Results and Discussion

Table 3 summarizes the results of the final inspection of soil stakes after 8½ years of exposure, plus pertinent retention data. Since retention ranges varied somewhat among the different treatments, some selection on the basis of preservative retention seemed advisable in calculating average decay and termite grades. Therefore, Table 3 contains data only for those stakes that fell within the retention range of 4 to 12 pounds per cubic foot, inclusive. This accounts for the fact that the number of stakes inspected varies among the different treatments. Despite this restriction, performance differences between different treatments were not well defined in all cases, because of differences in retention. In certain combinations, however, the bisphenols evidently contributed strongly to preservative effectiveness.

Three treatments proved to be definitely superior, as judged by the number of completely sound specimens and average decay and termite grades. These were:

A. 2.5 percent Compound G–4 in creosote + No. 6 fuel oil
F. 2.5 percent Compound 30 in creosote + No. 6 fuel oil
B. 2.5 percent Compound G–4 + 1.0 percent Cu as copper naphthenate, in 4A fuel oil.

The most effective preservative system included in the series was Treatment A. Of the stakes of this treatment that were within the 4 to 12 pound retention range, 81 percent were completely sound after 8½ years of exposure. Fifty-six percent of the stakes in Treatment F, and 69 percent of those in Treatment B were completely sound after an exposure of 8½ years.

It is also clear from the data in Table 3 that the treatments involving replacement of half the pentachlorophenol in 4A fuel oil with an equal amount of either Compound G–4 or Compound 30 (C and H) were substantially better than the treatment with pentachlorophenol alone (M).

Neither Compound G–4 nor Compound 30 alone, in No. 4A fuel oil or in Panalene SN, had marked wood-preservative effectiveness at the low concentration of 2.5 percent at which they were evaluated (Treatments E, J, D, and I). It therefore appears that the potential utility of these compounds for terrestrial wood preservation lies primarily in their use in combination with other toxicants. Both bisphenols might well be studied further as additives to creosote. The com-

Table 4.—TREATMENT-RETENTION DATA AND MARINE BORER RATINGS OF TREATED PANELS AFTER EXPOSURE IN SEA WATER FOR 1½, 2½, AND 4 YEARS

Treatment	Range of preservative retention lb./cu. ft.	Average borer rating after indicated exposure period[1]		
		1½ years	2½ years	4 years
A G-4 in creosote+No. 6 fuel oil	23.4–37.4	8.4	4.5	1.3
F —30 in creosote+No. 6 fuel oil	27.5–36.4	8.9	5.3	0
K Creosote	22.6–34.6	9.6	8.1	4.5
B —G-4+copper naphthenate in 4A fuel oil	29.8–32.0	9.9	9.3	6.8
G —30+copper naphthenate in 4A fuel oil	27.2–31.9	9.8	8.9	1.5
L —Copper naphthenate in 4A fuel oil	28.2–29.7	9.1	4.5	0
C —G-4+pentachlorophenol in 4A fuel oil	26.4–28.4	4.0	[2]	
H —30+pentachlorophenol in 4A fuel oil	23.1–28.2	0	[2]	
M Pentachlorophenol in 4A fuel oil	27.2–28.9	2.8	[2]	
D G-4 in Panalene SN	33.5–35.7	8.5	3.6	0
I —30 in Panalene SN	34.7–36.2	8.3	2.9	0
N —Panalene SN	25.6–32.5	7.9	3.6	0
E —G-4 in 4A fuel oil	21.5–25.0	2.0	[2]	
J —30 in 4A fuel oil	25.0–26.3	0	[2]	

[1]Average of 4 specimens. In the rating scale used, a rating of 10 = perfect, no borer attack; 0 = destroyed by borers.
[2]Removed at 1½-year inspection.

bination of Compound G–4 with copper naphthenate also appears to have definite promise.

Marine Panel Series: Table 4 gives the treatment-retention ranges of the marine test panels, and borer ratings after three exposure intervals. Treatment B (2.5 percent Compound G–4 + 1.0 percent Cu as copper naphthenate, in 4A fuel oil) was superior to all other treatments at each of the three inspections. Even after 4 years of exposure, the average rating for the four panels treated with this solution was 6.8, compared to an average rating of 4.5 for the next best preservative, Treatment K (creosote). None of the other treatments included in this series was sufficiently effective to warrant further consideration.

In view of the relatively good performance of the copper naphthenate—Compound G–4 combination, there would seem to be good justification for investigating it further. It would be particularly interesting to evaluate various ratios of copper naphthenate and Compound G–4 as supplemental toxicants for improving the performance of creosote, or creosote-coal tar solutions as marine wood-preservatives.

Summary and Conclusions

Both of the bisphenols included in this study, 2,2′–methylenebis–(4–chlorophenol) and 2,2′–thiobis(4–chlorophenol), definitely contributed to the effectiveness of certain standard wood-preservative toxicants, when used in combination with the latter. In soil exposures, this contribution was particularly evident when either of the bisphenols was used in conjunction with creosote, and when 2,2′–methylenebis(4–chlorophenol) was used with copper naphthenate. A definite gain in performance was also found when either bisphenol was substituted for half the pentachlorophenol in a solution of pentachlorophenol in 4A fuel oil.

Under marine exposure conditions, the combination of 2,2′–methylenebis (4–chlorophenol) with copper naphthenate showed considerable promise. It was substantially more effective than copper naphthenate alone in controlling marine-borer attack.

Neither of the bisphenols was found to possess marked wood-preservative activity when used as the sole toxicant in treating solutions.

It is concluded that the two bisphenols evaluated merit further consideration as adjuvants or co-toxicants in creosote, creosote-coal tar, and copper naphthenate wood-preservative treatments for terrestrial and marine service. The results of the exploratory experiments described above are presented here as a guide to other workers who may be interested in investigating the bisphenols for these applications.

BOOK REVIEW

Cronin, J. E.: Hermann von Schrenk: A Biography. Published by Cronin, Kuehn, McCormick Bldg., Chicago, 1960. 224 pp. Price, $4.50.

This book is of special interest in depicting the stormy and brilliant career of Dr. von Schrenk and in providing a picture of the development of the wood preservation industry during the first half of the twentieth century.

Historians have long recognized the importance of the perspective of time in evaluating and appraising the significance of events and the personalities associated with them. In writing this biography just six years after Dr. von Schrenk's death, Dr. Cronin has sacrificed somewhat the perspective of time but has gained an invaluable asset in the current availability of records and documents not yet effaced by time and of contact with former colleagues, associates, friends, and acquaintances who still have vivid recollections of his career and his life. Out of this wealth of documentary material and personal interviews, Dr. Cronin presents an interesting and fascinating account of the dynamic life and deeds of Dr. von Schrenk.

The author has effectively succeeded in portraying Dr. von Schrenk's career both objectively and sympathetically, and all facets of his life and personality are recorded. In an overall appraisal Dr. Cronin states:

"If von Schrenk had simply supplied the railroads with the information they needed (on selection and preservative treatment of ties) there would have been no occasion for a biography; a few lines in a government pamphlet at the head of his long list of publications would have sufficed. But von Schrenk was an extraordinary individual. His brilliance was almost legendary. His self confidence was gargantuan. His arrogance was colossal. His capacity for work was unmatched. His curiosity was insatiable. As a monologist he was breath taking.

Dr. von Schrenk's training in botany and pathology brought him face to face with the problem of decay in timber. His practical instinct here led him away from the purely academic to the realistic world of decay prevention, in which methods of preservative treatment of railroad ties became a major activity. Dr. Cronin, thus, colorfully appraises von Schrenk's activities in this field:

"The romance of the railroad has always been the big train; great thundering symbol of our unappeasable hunger for far away places, it has haunted our folklore and the dreams of our literary men. The track, too, is a symbol, less dynamic but no less familiar; two gleaming parallel lines reaching off toward the horizon with the beguiling promise that they will meet.

"But the railroad tie—what can be said of that?

6″ x 8″ x 8′; 7″ x 9″ x 8′6″

So the specifications read. A rough hewn chunk of wood, probably the most utterly utilitarian, functionally designed object in the whole range of commerce and industry. And when the tie is ready for the track, thoroughly impregnated with creosote to make it durable, it is even less attractive than before.

"Could a railroad tie conceivably capture the imagination? As a subject does it have any interest? As an object, except as something shoved under a track, has it any importance? The answers to these are yes and yes, and yes again!"

The biography covers a review of the research on controversial features of the characteristics of wood preservatives and the technique of treating wood in which Dr. von Schrenk was engulfed. It is particularly interesting as an historical record of the battlefield of wood preservation. The technical dissertation is a remarkable tribute to the versatile pen of the author.

The biography is replete with stories and anecdotes of his life and contacts that illustrate von Schrenk's brashness, his dedication, and his dynamic and convincing personality. Dr. Cronin concludes with this comment:

"He is gone now. With his going went the excitement and the color. Once again a railroad tie is simply a large ugly chunk of wood, and treating it a rather dull and routine procedure. Even those whose hackles rose at the very sound of his name in the convention corridors would, if you asked them straight, admit that things have changed and they would like the old days back. 'The Doctor has made things go!' they say. 'We miss him.' What was this magic?"

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A NEW METHOD FOR CHARACTERIZING

Mixtures of Creosote and Petroleum Oils[1,2]

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A new, rapid, convenient, and sensitive selective-solvent method for characterizing blends of creosotes and petroleum oils is described. It has been termed the "glycol-insoluble method." Correlation between characterization data and fungitoxicities of preservative oils will be discussed in a companion paper.

INTEREST IN THE DEVELOPMENT of methods for assaying blends of creosote and petroleum stems from two causative factors. In the first case, the petroleum is not wanted since the consumer who specifies creosote wants assurance that the preservative has not been adulterated or extended with petroleum derivatives. In the second case, the petroleum is a required ingredient since other consumers, such as railroad purchasers who specify treatment with creosote-petroleum solutions, desire proper definition of the solution and practical control methods in the treating plant. Use of these two types of preservatives in a treating plant, as well as solutions of pentachlorophenol in creosote or in petroleum oils, frequently introduces complicated problems of potential cross-contamination through pumps and pipelines.

Early efforts to develop quantitative methods for determining the percentages of creosote and petroleum in a given solution, either new or used, are described in reports of the Preservatives Committees in Proceedings of the American Wood Preservers' Association (AWPA) from 1926 through 1932. In 1932 (1),[3] the early work was summarized with the conclusion that no separation method was known that was applicable to the analysis of unknown mixtures where a high degree of accuracy was desired. It was concluded further that the three methods that had been under consideration, specific-gravity comparisons, sulfoacetic acid solvency, and dimethyl sulfate solvency, could be useful for plant-control work only if the characteristics of the ingredient oils were known.

Baechler (2) and Mayfield (3) reviewed the status of the problem in 1945 and 1950. Mayfield, reinforced by the report of AWPA Preservatives Committee P–3 (4), of which he was then chairman, emphasized comparison of various methods and suggested that all of the methods had shortcomings. He indicated, however, that the "Sheridan" triethylene glycol-furfural method offered the most promise for plant control when samples of the original creosotes and petroleums were available.

Since then Stasse (5) has worked with the triethylene glycol-furfural system, thoroughly investigating various ratios of the two solvents and of solvent to sample, and improving the accuracy of estimating results. His improved procedure, referred to as the TEG–F method, is a rapid characterization tool.

In 1953, Heiks, Blum, and Burch (6) described another selective-solvent method based on the selective solvency for highly aromatic compounds of β,β'–oxydipropionitrile (ODPN) in the presence of an aliphatic solvent. In 1955, Heiks and associates (7) presented a simpler modification of the ODPN method and compared the results with those obtainable by the TEG–F method and by comparison of the specific gravities of distillation fractions. They concluded that both the ODPN and TEG–F methods were rapid and simple analytical procedures, and that both were superior to the specific-gravity-of-fractions method for detecting petroleum in creosote.

All of the methods that have been considered for the determination of petroleum in creosote-petroleum solution have been based on aromaticity differences between creosote and petroleum constituents. Part of the difficulty in interpreting results of the various methods has been due to the fact that petroleum oils contain varying amounts of highly aromatic compounds.

Heiks (12) discussed some of the factors that influence the distribution of aromatic, aliphatic, and aliphatically substituted aromatic compounds between ODPN and a solvent naphtha. The same considerations are applicable to the glycol-insoluble test, that involves a partition of compounds between triethylene glycol and a solvent naphtha. It is incorrect to assume that there is an absolute separation of all aromatics from all aliphatics or substi-

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[2] Bernuth, Lembcke Company, Inc., New York City provided financial support for this investigation and gave permission to publish the results. Special thanks are extended to J. S. Furr of Battelle for laboratory assistance.

[3] Numbers in parentheses refer to Literature Cited at the end of this article.

tuted aromatics in these two tests, or that there is an absolute separation of all petroleum components from all creosote components. Even single, pure compounds are distributed between the solvent for aromatics and the solvent for aliphatics. With the complex mixtures of compounds that exist in creosote and petroleum oils, the solubilizing effect of one compound for another greatly complicates the picture. Therefore, it seems best to regard these tests as empirical means of separating components in such complex systems and to look at the insolubility data as "indices," rather than as specific measurements, of aromaticity. The indices are useful in defining creosote or creosote-petroleum solutions.

The solubility indices also appear to have a unique biological significance. Heiks and associates (8, 9) reported the results of exploratory laboratory soil-block culture tests (10) on four oils derived from widely different sources, using unweathered blocks and *Lentinus lepideus* as the test fungus. The experiments were run to determine the relationship between ODPN–insoluble data and the initial preservative potential of the whole oils, of the ODPN-insoluble fractions and of the ODPN-soluble fractions. The initial preservative potential is defined here as the threshold retention, under the conditions of the test (10), i.e., the amount of preservative used for treatment, in pounds per cubic foot of wood, that only prevents attack by the test organism on the treated unweathered blocks. These first experiments indicated a relation between the ODPN-insoluble values of the distillates to coke and the initial preservative potential of the whole oils, and suggested that the ODPN value might be used as an index of inherent preservative quality. Furthermore, since some aromatic compounds in certain petroleum oils are chemically identical to some in creosote, it was not surprising to find that the threshold values for the ODPN-soluble materials were almost identical, regardless of creosote or petroleum origin. The threshold values for the whole oils, however, varied directly with the ODPN-insoluble values.

Snoke (11) reported in 1957 that with "coal tar creosote ODPN values are lowest while with petroleum oils the values are much higher. It is clear, too, that as the ODPN-insoluble values increase, the threshold values increase. In other words, the preservative efficiency of these oil-type materials appears to decrease with increasing ODPN-insoluble values. There are definite indications here of a correlation between a rapid chemical test and the longer biological assay."

ODPN has since been removed from the commercial market by its manufacturer. The purpose of this paper is to describe an alternative selective-solvent method of characterization that appears to be a completely adequate replacement for the ODPN test.

Experimental Procedure

General Approach: A suitable method for the determination of petroleum in blends with creosote should be rapid, simple, reproducible, and reasonably accurate, and its use should constitute no health hazard for the operator. The ODPN method generally fulfilled all these requirements, with the advantage that the results appeared to correlate with initial preservative potential. Triethylene glycol, a recognized solvent for aromatics, was found promising as a direct replacement for ODPN. However, further experimentation was directed toward evolution of an even more simplified procedure for its application. The new method is volumetric rather than gravimetric. It is called the "Glycol-Insoluble" method to distinguish it from Stasse's TEG-F method.

Glycol-Insoluble Determinations: *Preparing The Sample:* To facilitate distinguishing and separating the two liquid phases, a sample of the oil in question is first distilled to coke. This can be accomplished by distilling about 100 ml. of the oil from a 200-ml. distilling flask at the rate of about 2 drops per second. The distillate is collected in any suitable glass container that can be closed tightly. If a rubber stopper or a screw cap with a paraffin-coated lining is used to close the container, a sheet of aluminum foil should be inserted to prevent these materials from coming into contact with the distillate vapor during long periods of storage or when the distillate is heated and shaken to assure uniformity.

Apparatus: Apparatus needed must include: 1) distillation equipment, ASTM Method D850; 2) centrifuge (International Centrifuge, Fisher 5–101–5, with 5–103B or 5–103C head and Fisher 5–170 50-ml. metal shields with Fisher 5–180 trunion rings, or equivalents); and 3) centrifuge tubes, 50-ml. (Fisher 5–540, graduated in 1-ml. divisions, or equivalents). Unmodified clinical centrifuges will accommodate only "short-form" 50-ml. centrifuge tubes. The only suitably graduated tubes on the market for this analytical procedure have a pouring spout which may cause leakage when the tube is stoppered and shaken. It may be necessary to have a glass blower straighten the pouring spout or to order tubes without the pouring spout on special purchase. Other alternatives are

Table 1.—AWPA FLASK DISTILLATION AND SPECIFIC GRAVITY DATA FOR VARIOUS CREOSOTE OILS

Creosote	AWPA Distillation, percent by weight: Distillate Fractions, °C. To 210	210–235	235–270	270–315	315–355	Residue	Specific Gravity, 38/15.5° C.: Whole Oil	Distillate Fractions, °C. 235–315	315–355
1 B	2.9	15.3	25.7	20.6	16.8	17.9	1.005	0.991	1.038
2 B	0.7	4.2	20.8	30.7	25.3	17.4	1.020	0.977	1.035
3 B	1.4	16.5	23.8	17.1	19.2	21.1	1.034	1.007	1.073
4 VR	0.1	3.0	14.3	25.2	30.4	25.9	1.021	0.996	1.031
5 VR	1.3	17.1	29.2	23.1	15.6	12.9	1.012	0.994	1.035
6 VR	3.3	14.6	23.0	20.8	21.3	17.1	1.037	1.007	1.067
7 HR	2.1	21.3	23.0	18.8	21.9	11.8	1.052	1.032	1.108
8 CO	0.0	3.8	19.5	30.2	31.6	14.5	1.085	1.055	1.123
9 CO	1.8	13.3	26.5	21.6	23.3	12.8	1.061	1.035	1.122
10 CO	0.0	13.1	27.2	17.9	25.2	15.9	1.078	1.049	1.120
11 CO	0.0	15.6	26.1	17.6	21.3	16.7	1.070	1.048	1.126
12 CO	0.0	5.6	30.2	19.4	24.7	19.3	1.085	1.051	1.121
13 CO	0.4	4.0	15.4	18.5	26.0	35.1	1.100	1.048	1.127
14 CO	1.3	10.2	20.7	12.6	23.7	30.7	1.094	1.045	1.123
15 CO	0.0	5.7	23.1	18.8	23.0	28.6	1.091	1.040	1.120
17 CO	0.6	12.1	28.8	18.8	20.6	18.6	1.072	1.037	1.125
18 CO	0.0	4.5	17.9	16.9	30.1	30.4	1.093	1.032	1.127
19 CO	0.0	9.4	23.9	15.4	23.2	27.0	1.095	1.050	1.143
Coop. 7	0.9	8.2	22.3	20.2	27.4	20.5	1.077	1.043	1.124
Coop. 9	3.2	7.3	21.1	23.1	24.9	20.0	1.001	0.978	1.021
Coop. 10	0.9	6.2	26.1	26.6	24.3	15.2	1.068	1.044	1.116
Coop. 11	1.0	7.6	23.1	24.1	25.3	18.0	1.038	1.012	1.065

Table 2.—AWPA FLASK DISTILLATION AND SPECIFIC GRAVITY DATA FOR VARIOUS PETROLEUM OILS

Petroleum	AWPA Distillation, percent by weight: Distillate Fractions, °C. To 210	210–235	235–270	270–315	315–355	Residue	Specific Gravity, 38/15.5° C.: Whole Oil	Distillate Fractions, °C. 235–315	315–355
P 1	0.0	0.0	14.3	51.4	29.2	4.6	0.888	0.879	0.899
P 2	0.0	0.0	18.0	54.0	25.0	2.5	0.956	0.942	0.994
P 3	0.0	0.0	0.4	8.2	40.1	50.7	0.909	0.870	0.885
P 4	0.0	1.4	35.7	50.9	6.4	5.7	0.922	0.920	0.955
P 5	0.3	2.0	12.9	21.1	16.8	46.3	0.990	0.925	0.955
P 16	0.0	0.8	12.2	33.4	28.6	24.1	1.045	0.997	1.055
Coop. 14	0.0	0.0	0.1	1.0	10.0	88.4	0.952	-----	-----

to use a larger centrifuge or cut holes in the bottoms of the metal tube shields, designing suitable rubber cushions for the bottom.

Also needed are 4) rubber stoppers, no. 6 and 5) a rack for holding centrifuge tubes.

Reagents: Necessary reagents are triethylene glycol (TEG), technical grade; and Skellysolve C, a commercial solvent naphtha, predominantly heptane.

Method: Fill a centrifuge tube exactly to the 20.0-ml. mark with triethylene glycol (TEG). Add Skellysolve C exactly to the 30.0-ml. mark. Add the distillate to coke of the oil sample, bringing the level of the liquids in the tube exactly to the 40.0-ml. mark. The tube then contains 20.0 ml. of TEG, 10.0 ml. of Skellysolve C, and 10.0 ml. of the distillate to coke of the oil that is to be tested. Close the tube with a tight-fitting rubber stopper and shake vigorously with an end-to-end motion for one minute, holding the stopper in place with thumb or index finger. Carefully remove the stopper to prevent loss of liquid and wipe the bottom of the stopper across the inner edge of the lip of the tube to remove any liquid that might cling to it. Centrifuge the tube for 5 minutes at about 1500 rpm. Remove the tube from the centrifuge. Read the level of the interface between the two liquid phases, estimating to the nearest 0.1 ml. Subtract this reading from 30.0. Multiply the difference by 10, and record the result as glycol-insoluble, percent by volume.

The volume readings must be made carefully to obtain accurate results. The centrifuge tubes always should be in a vertical position when volumes are being read. The rack has been devised for this purpose. Holes slightly larger than the diameter of the tubes, but smaller than the rim at the top, are drilled in a piece of ¼-inch plywood or thin, but reasonably rigid, metal. This drilled piece is then rigidly mounted to any suitable support and adjusted with a spirit level to make certain that it is horizontal. As long as the drilled piece remains horizontal, the centrifuge tubes will hang from it in a vertical position. If these instructions are followed carefully, a single operator usually can obtain results that do not deviate more than ± 1 percent in duplicate determinations.

Oil Samples: The creosote and petroleum oils that were used in this study have been described in earlier reports (6,12,13,14). The creosote oils were representative of certain domestic and imported creosotes, and the petroleum oils were representative of inexpensive "aromatic" oils; all were available about 1950. Creosote oils 1 B through 15 CO (Table 1) and 17 CO through 19 CO, as well as petroleum oils P 16 and P 1 through P 5 (Table 2) have been described previously (6, 12). In the sample designations used for these oils, VR indicates that the creosote was distilled from a vertical-retort tar; HR means that the source was a horizontal-retort tar; CO means that it was a coke-oven tar; B means that it was a blend of tars, predominantly of vertical-retort origin; and P means that the product had a petroleum background. Among the CO samples, 8 CO through 12 CO represent imported coke-oven creosotes; whereas 13 CO through 19 CO represent domestic coke-oven creosotes.

Table 3.—GLYCOL-INSOLUBLE AND ODPN-INSOLUBLE DATA FOR VARIOUS CREOSOTE OILS

Creosote	Glycol-Insoluble, percent by volume	ODPN-Insoluble, percent by weight
13 CO	42	48
14 CO	43	46
19 CO	43	48
5 VR	44	47
Coop. 7	46	51
15 CO	47	50
6 VR	48	50
8 CO	48	52
7 HR	49	48
12 CO	49	50
17 CO	49	52
9 CO	50	50
10 CO	50	51
Coop. 10	50	51
3 B	50	52
11 CO	50	52
18 CO	50	52
2 B	50	54
Coop. 11	52	51
Coop. 9	53	53
4 VR	56	53
1 B	60	59

Table 4.—GLYCOL-INSOLUBLE AND ODPN-INSOLUBLE DATA FOR VARIOUS PETROLEUM OILS

Petroleum	Glycol-Insoluble, percent by volume	ODPN-Insoluble, percent by weight
P 16	68	70
P 2	88	86
P 4	94	86
P 1	94	89
P 5	94	90
Coop. 14	94	92
P 3	97	90

Creosote oils Coop. 7, 9, 10, and 11 and petroleum oil Coop. 14 have been used in a cooperative creosote study (13, 14). Coop. 7 was a domestic coke-oven tar creosote, Coop. 9 was an imported vertical-retort tar creosote, Coop. 10 was an imported coke-oven tar creosote, and Coop. 11 was a 50/50 by volume blend of Coop. 9 and Coop. 10.

All of the petroleum samples were of domestic origin. Samples P 1, P 2, P 4, and P 5 were designated by their producers as aromatic petroleum oils. P 3 was not so designated. Sample P 16 was a highly aromatic distillate from an oil-gas tar. Coop. 14 was a heavy residual petroleum oil.

Experimental Results and Data

Table 1 is a compilation of AWPA-distillation and specific-gravity data for the 22 creosote oils used in this study. Table 2 shows comparable data for the seven petroleum oils. Most of the data in these two tables, necessarily repeated to facilitate reference, have been assembled from the earlier papers, but some of the figures were obtained recently at Battelle. Tables 3 and 4 show solvent characterization data, determined by the glycol-insoluble and ODPN-insoluble methods for the respective creosote and petroleum oils listed in Tables 1 and 2.

Table 5 shows compositions of four blends of various creosote and petroleum oils listed in Tables 1 and 2, as well as AWPA-distillation and specific-gravity data. Table 6 shows selective-solvent characterization data for the blends and apparent compositions as calculated from such data.

Discussion

The data in Tables 3 and 4 indicate that the glycol-insoluble and ODPN-insoluble values for a particular oil are about the same. To test the methods for the actual detection or determination of petroleum in creosote, four blends, containing from 15 to 30 percent petroleum, were prepared from some of the oils shown in Tables 1 and 2. Table 5 shows the compositions of these blends, as well as AWPA-distillation and specific-gravity data for them. All of the blends meet the specific-gravity specification for the whole oils and for the 315° to 355° C. distillation fractions. Two of them, BL 1 and BL 3, are slightly below the minimum specific gravity for the 235° to 315° C. fraction.

Solvent-insoluble data for these blends are shown in Table 6. The glycol-insoluble values for all of the blends are outside the limits for creosote oils in Table 3 (excluding 4 VR and 1 B), but the ODPN-insoluble values are within the limits for creosote oils. Therefore, the glycol-insoluble method could be used successfully to detect the presence of petroleum in these particular blends, but the ODPN-insoluble method could not.

Table 6 also shows how the solvent-insoluble data might be used to determine compositions of blends if data were available for the component oils as well as for the blends. Apparent compositions calculated from glycol-insoluble data are generally closer to actual compositions than are those cal-

Table 5.—CHARACTERISTICS OF VARIOUS BLENDS OF CREOSOTE AND PETROLEUM OILS

	Blend Numbers and Compositions's			
	BL 1 80% 8 CO 20% P 5	BL 2 70% 11 CO 30% P 16	BL 3 85% 12 CO 10% P 5 5% P 3	BL 4 75% Coop. 7 20% P 16 5% P 3
AWPA distillation, percent by weight				
Below 210° C.	0.4	0.0	0.0	0.5
210–235° C.	3.8	7.4	5.9	6.4
235–270° C.	16.5	27.3	26.1	19.9
270–315° C.	27.3	20.3	19.0	21.7
315–355° C.	26.5	21.6	25.3	28.3
Residue	25.1	21.7	23.6	22.2
Loss	0.4	1.7	0.1	1.0
Specific gravity, 38/15.5° C.				
Whole oil	1.067	1.065	1.068	1.065
235–315° C. fraction	1.024	1.030	1.021	1.025
315–355° C. Fraction	1.108	1.091	1.085	1.095

Table 6—SELECTIVE-SOLVENT CHARACTERIZATION DATA AND APPARENT COMPOSITIONS OF VARIOUS BLENDS OF CREOSOTE AND PETROLEUM OILS

	Blend Numbers and Compositions			
	BL 1 80% 8 CO 20% P 5	BL 2 70% 11 CO 30% P 16	BL 3 85% 12 CO 10% P 5 5% P 3	BL 4 75% Coop. 7 20% P 16 5% P 3
ODPN-insoluble, percent by weight	54	52	53	51
Glycol-insoluble, percent by volume	60	56	56	57
TEG-F-insoluble, percent by volume	10	12	0	2
Apparent Composition*				
ODPN Method, percent by weight				
Creosote	95	100	92.5	100
Petroleum	5	0	7.5	0
Glycol Method, percent by volume				
Creosote	74	67	85	61
Petroleum	26	33	15	39
TEG-F Method, percent by volume				
Creosote	88	72	100	96
Petroleum	12	28	0	4

*Apparent compositions were calculated from solvent-insoluble data for component oils and blends, using formula: % Insoluble (blend) = X(% insol., creo.) + (1—X) (% insol., petrol.)
For example, the apparent composition of BL 1 by the ODPN method is:
54 = X(52) + (1 — X)(90) = 52X + 90 — 90X
38X = 36
X = 0.95 = 95% creosote
1—X = 0.05 = 5% petroleum
When two petroleum oils were used in a blend, a weighted average was used as the solvent-insoluble value for the total petroleum portion.

culated from data obtained by either of the other two methods. All three methods gave rather poor results with one blend (BL 4), but the composition calculated from glycol-insoluble data is more accurate than are those obtained by the other methods. Thus, the glycol-insoluble method appears to be a good tool for control analyses of creosote-petroleum blends in treating plants.

It should be emphasized that the new method is not merely a replacement for the ODPN test; it is more advantageous. The two methods are about equally reproducible, but the glycol-insoluble method, being volumetric rather than gravimetric, is more rapid and more easily performed. In addition, the preliminary work with blends of creosote and petroleum oils indicates that the glycol-insoluble data are more sensitive to the presence of petroleum and more accurate in determining the petroleum content of a blend. The correlation of solvent-insoluble data with initial preservative potential is discussed in a companion paper, which was prepared in cooperation with Bell Telephone Laboratories, Inc.

The creosote and petroleum oils that were used in this study were collected several years ago, and they may no longer be strictly representative of oils that are on the market today. A supply of currently available oils is being collected, and it is hoped that data obtained in present studies can be correlated with data on the current oils.

Summary and Conclusions

Triethylene glycol (TEG) and Skellysolve C, a solvent naphtha, predominantly heptane, can be used in the recommended proportions as a two-component selective-solvent system to detect the presence of petroleum or petroleum products in creosote-petroleum solutions, either as adulterants or as desired components in such solutions. The test is based on the partition of the more aromatic, the less aromatic, and the aliphatic constituents of such blends between the two solvents.

The test is an empirical one. The complex solubility relationships operating in its application are at present not clearly definable.

The data are determined on a volumetric basis, and they are reported as percent glycol-insoluble. The insoluble values or "indices" agree closely with data previously obtained with the ODPN test. Since ODPN (β,β'–oxydipropionitrile) is no longer commercially available, the glycol-insoluble method is suggested as a completely satisfactory replacement for the earlier ODPN procedure. It can be more rapidly and more easily performed than the latter. It is a sensitive test for the detection of petroleum or petroleum derivatives in creosote. Both ODPN-insoluble and glycol-insoluble indices appear to be definitely related to the initial preservative potential of the oils tested.

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BIOLOGICAL SIGNIFICANCE OF

ODPN—Insoluble and Glycol-Insoluble Tests[1]

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HEIKS AND CO-WORKERS (1,2,3,4, 6)[2] of the Battelle Memorial Intitute reported studies on numerous reosotes and petroleums aimed at deeloping a procedure for determining he presence and the amount of petroeum that might be blended with the reosotes. A chemical method using ODPN (β,β'—oxydipropionitrile) as selective solvent for the highly aromatic constituents seemed promising; was based on the partition of compounds in creosote or in petroleum between ODPN and a solvent naphtha. With use of the soil block method (see ASTM D1413-56T) and unweathered treated blocks, they found that the ODPN-soluble fraction of these oils was more toxic to *Lentinus lepideus* than the ODPN-insoluble fraction; and that the higher the ODPN value the higher the threshold retention. They, therefore, suggested that the value for ODPN-insoluble, the easier of the two values to determine directly, might serve as an index of initial preservation potential. Snoke (5) confirmed this and emphasized that the insolubility data obtained by the chemical ODPN test correlated with the unweathered block thresholds in the soil-block test, and that definite correlative evidence existed between the simple short chemical test and the longer biological assay.

After ODPN was removed from the market, Burch and Colley (7) developed an alternative chemical method, the "glycol insoluble" method, as a substitute for the ODPN procedure. It is also based on the partition of aromatic and aliphatic compounds in creosotes and petroleum oils. Results obtained correlate closely with the results of the ODPN procedure. It is considered to be more sensitive to the presence of petroleum in blends of petroleum and creosote than the ODPN method. A condensed review of the problem to date, and a description of the glycol-insoluble method, with characterization data for a number of creosotes and petroleums oils, and blends of the two, is available (7).

[1] A contributed paper approved for publication January 24, 1961.
[2] Numbers in parentheses refer to the references at the end of the article.

Evidence that ODPN-insoluble values are related to the toxicity of creosote and creosote = petroleum mixtures, gives fungicidal significance to the ODPN data and to the glycol-insoluble valeus as well. (7) This biochemical relationship offers possibilities for a quick chemical test to determine whether an oil has basic wood preserving potential, instead of the longer soil-block bioassay method which takes about 5 months.

Experimental Procedure

The creosote and petroleum oils, consisted of creosotes, creosote–petroleum blends, and petroleums (Table 1). Characterization data, in Table 2, were determined by Battelle; Bell Laboratories conducted the soil-block bioassays to determine the unweathered block thresholds. The characterization data include distillation patterns for standard American Wood-Preserver's Association flask distillation.

Eight samples with varying ranges of ODPN–insoluble indexes were evaluated. It was unnecessary to weather the blocks during tests, as selective-solvent methods are considered to be tests of possible preservative potential of the oils "as received." Evaluation of permanence characteristics was, therefore, not applicable. Several retentions were used for each oil in order to straddle the anticipated thresholds. Ranges of retention were from 1 to 6 pounds per cubic foot of wood for the creosotes, and 5 to 30 pounds per cubic foot of wood for the blends and the petroleums.

Ten blocks for each retention of each treatment were exposed to the test organism, *Lentinus lepideus*, Madison 534. The blocks were incubated at 80° F. and 70 per cent RH. After incubation for 90 days, weight losses were measured; and the threshold was determined statistically by the regression line method, a method based on weight loss and retention values (8).

Results

The results of the bioassay work are shown in Table 3 with the ODPN-insoluble values and the threshold retention for each oil, together with the associated glycol–insoluble values reported by Colley and Burch. The whole creosotes (6011, and Coop 7) give the expected low solvent-insoluble values and low thresholds for unweathered blocks. These values are consistent with those determined for coal-tar creosotes of satisfactory wood preserving qualities. Evidence shows

SOLVENT-INSOLUBLE index versus soil-block threshold for creosote and petroleum oils.

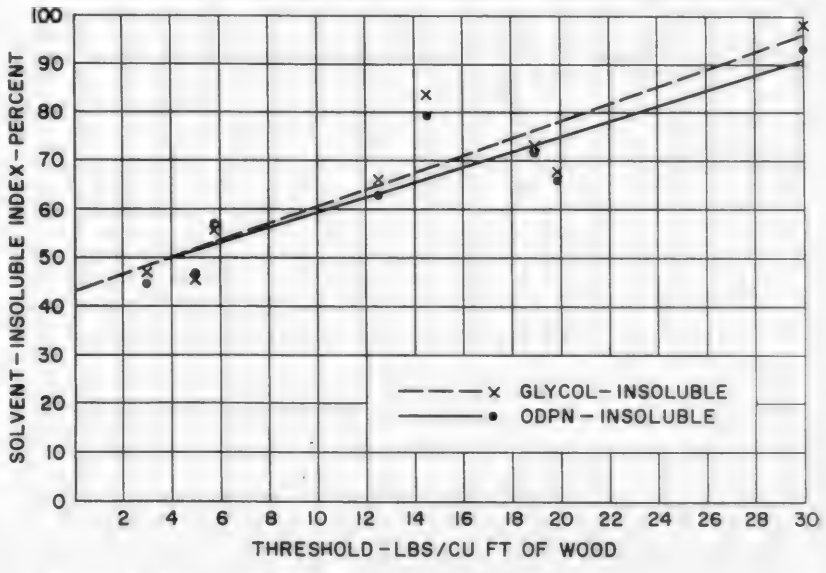

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Table 1.—OILS USED IN THE SOIL-BLOCK TESTS

Bell Labs. No.	Battelle No.	Oil Type
6011	16 VR	Imported vertical retort tar creosote
Coop. 7	Coop. 7	Domestic coke oven tar creosote
6039	20 LT	Low temperature coal tar creosote
6040	P 16	Oil gas tar distillate
6041	PCN 30	Petroleum, Panalene SN
6042	PCN 14	Petroleum, grade B diesel fuel
6058	AD 49	Blend: 61.8 per cent coke oven tar creosote (19 CO) and 38.2 per cent petroleum (P2) by weight
6067	AD 51	Blend: 33.3 per cent of coke oven tar creosote and 66.7 per cent petroleum (PCN11) by weight

(7) that the upper limit of the ODPN-insoluble values for such creosotes is about 55 and the corresponding glycol-insoluble value about 53. Of course, values near and just below this level may be found when small quantities of certain highly aromatic petroleum derivatives are blended with the creosote. Characteristics such as distillation pattern, specific gravity of whole oil and fractions, and other recognized tests would have to be considered with borderline oils.

The glycol-insoluble and the ODPN-insoluble values for the low-temperature tar creosote (6039) are transitional above the whole coal-tar creosote range but below the other values in the table. The petroleum oils showed high solvent-insoluble values and correspondingly high thresholds. The thresholds for the mixtures of creosote and petroleum (6058 and 6067) fall in an intermediate position between whole creosote and whole petroleum in accordance with their solvent-insoluble values.

By plotting the thresholds of these various oils against their ODPN-insoluble values, a straight-line relationship may be determined by the method of least squares (Figure). The glycol-insoluble data are plotted similarly in the figure. There is little deviation between the two lines, and agreement in the creosote area is satisfactory. The divergence in the broad petroleum area is not of major importance. Since both methods are empirical, the insolubility data should be regarded as "indices" rather than as specific measures of aromaticity in the oils.

Petroleum 6042 completes the picture by giving a high insoluble value and a high threshold. Although petroleum oil 6041 shows a high threshold, the threshold lacks the magnitude indicated by its high ODPN or glycol indices. Despite evidence of toxicity, oil 6041 is not comparable to the whole creosote oils. This fact has been confirmed in field tests on pole diameter posts, which at an 8-pounds-per-cubic-foot retention level by gauge, begin to decay within a 12-year period. The threshold data for oil 6041 indicate that it contains either an unusually high quantity (for a petroleum oil) of a fungitoxic compound or a moderate quantity of a highly fungitoxic compound. This conjecture could probbaly be verified by comparison of the thresholds of fractions of this oil with those of similar fractions of other oils, but such tests have not been made.

The data presented confirm and supplement the inferences in previous reports that there is a definite and measurable relationship between the values obtained by the ODPN-insoluble and glycol-insoluble tests and the unweathered block thresholds for *Lentinus lepideus* that were obtained by the soil-block test.

Table 2.—CHARACTERIZATION DATA FOR CREOSOTES, PETROLEUMS, AND CREOSOTE-PETROLEUM BLENDS

	6011 16VR	Coop 7	6039 20LT	6040 P16	6041 PCN30	6042 PCN14	6058 AD49	6067 AD51
Distillation, percent by weight AWPA Flask								
To 210° C	4.8	1.0	1.4	0.0	0.0	0.0	0.0	0.0
210°–235°	15.6	7.6	3.0	0.9	14.2	0.0	3.7	0.5
235°–270°	21.9	23.6	11.5	14.0	59.0	28.9	24.5	20.3
270°–315°	20.1	20.0	18.6	32.7	14.2	58.6	27.5	31.5
315°–355°	18.4	27.9	37.7	25.3	----	10.5	25.3	19.1
Residue by dif.	19.2	19.9	27.8	27.1	12.6	2.0	19.0	28.6

Table 3.—ODPN- AND GLYCOL-INSOLUBLE DATA, AND UNWEATHERED BLOCK THRESHOLDS (*LENTINUS LEPIDEUS*)

Code Oil[1]	ODPN-Insoluble Percent by weight	Glycol-Insoluble Percent by volume	Unweathered Block Thresholds, lb./cu. ft. ASTM Tentative Standard	Unweathered Block Thresholds, lb./cu. ft. Bell Labs[2] Analysis, and 95 percent Confidence Limits
6011 VR Creosote	45	47	2.8 (2.0–3.0)	3.0 (2.8–3.2)
Coop 7 CO Creosote	47	46	4.8 (4.0–5.0)	5.0 (4.6–5.4)
6039 LT Creosote	57	56	5.8 (4.8–5.8)	5.8 (5.4–6.2)
6058 Blend	63	66	> 9.0	12.5 (Est. 12–13)[3]
6040 Oil-Gas-Tar Distillate	66	68	15.0–20.0	19.9 (17.2–22.6)
6067 Blend	72	73	18.0 (16.0–18.0)	19.0 (Est. 18–20)[3]
6041 Petroleum	79	84	11.8 (9.8–15.3)	14.5 (12.4–16.6)
6042 Petroleum	93	98	>30.0	>30.0

[1]See Table 1 for description of the oils.
[2]Based on Bell Telephone Laboratories procedure for statistical determination of threshold (3).
[3]Extrapolated from graphs on which retention and weight loss were plotted.

Conclusions

The results of bioassay tests indicate that a quick method for determination of the relative initial preservative potential of creosote and creosote-petroleum mixtures may be available to the wood-preserving industry. ODPN–insoluble test values are related to the expected unweathered block thresholds that might be obtained by soil-block bioassay. The same relationship holds for glycol-insoluble values since these have been shown to parallel the ODPN data. A glycol-insoluble index of 53 or less (7) corresponds generally to a satisfactory whole creosote. The petroleum with glycol-insoluble indices higher than 86 will have high thresholds usually, indicating unsatisfactory preservative performance. A creosote or a blend of questionable preservative potential would fall into a transitional zone of 54 to 85. This corresponds to an intermediate threshold position and suggests questionable field performance. Possible use for the ODPN or glycol-insoluble test is indicated not only for determination of the extent of petroleum additions to creosote but also as a measure of initial biological preservative effectiveness.

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Effectiveness of Stabilized Surface Layers of Wood As Moisture Barriers[1]

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Tests showed that chemical stabilization of the surface layers of wood produces an inefficient moisture barrier. Stabilization eliminates bound-water diffusion, but it has little effect on vapor diffusion.

ONE OF THE GOALS of the wood technologist is the development of process for stabilizing the dimensions of wood, which normally shrinks and swells with changes in relative humidity. Although several methods have been developed (5),[3] none is yet economically attractive. This is largely due to the cost of distributing chemicals throughout the wood. A logical question is: What is achieved by chemically stabilizing the immediate surface of wood? One would not expect any appreciable permanent stabilization. However, would the stabilized surface layer act as a moisture barrier and significantly retard the rate of penetration of water vapor into the untreated portion of the wood? Although this question cannot as yet be answered directly, results of experiments performed at the Forest Products Laboratory justify making certain predictions.

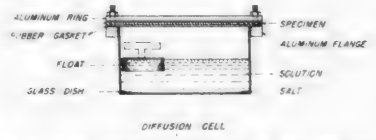

Fig. 1.—A schematic drawing of the diffusion cell used in this study.

Method

Yellow birch veneer (1/16-inch sapwood) was acetylated (7) to varying degrees. The rate of diffusion of moisture through these sheets was studied with equipment similar to that described by Burr and Stamm (1). Essentially, the veneer was sealed to a glass cup containing a saturated salt solution to establish a given relative humidity within the cup (Figure 1). These cups were rotated (Figure 2) in a room of controlled relative humidity and temperature (80° F.). The equipment was so designed that, on rotating the cups, the solution and air within the cups were stirred. The cups were weighed periodically to determine the rate of loss in weight. Typical data obtained in this work are plotted in Figure 3 from which the permeability constant, k, is computed. This constant is expressed as grams of moisture diffusing per hour across an area of one square centimeter and through a one-centimeter thickness of veneer when the partial pressure increment of water vapor across the veneer is one millimeter of mercury. This is not the conventional unit of the diffusion constant, but it is easier to compute since it does not require a knowledge of the equilibrium moisture content and density of the acetylated wood. Furthermore, as seen later, it permits comparison with published data. The values of k are shown in Table 1. These values are given for veneers of varying acetyl content, as measured at roughly the same relative humidity interval but at two levels of average relative humidity: a low level, 35 to 75 percent, and a high level, 58 to 90 percent.

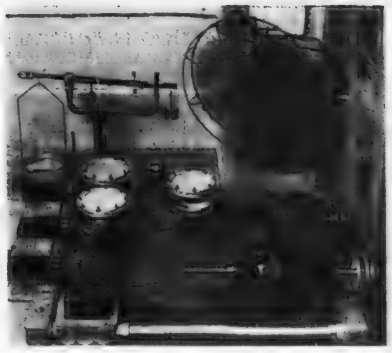

Fig. 2.—Diffusion equipment; the cups were rotated in this room of controlled humidity and temperature.

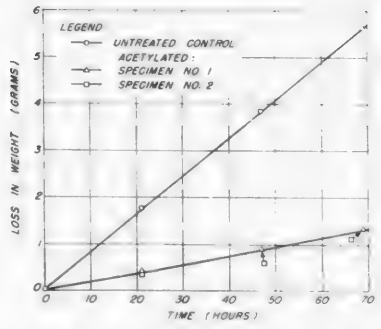

Fig. 3.—Typical data obtained in this study on weight loss versus time curve is shown; it is from this that the permeability constant, k, is computed.

Discussion

At the lower average moisture content level (established between 35 and 75 percent relaitve humidity), k for untreated wood is 0.98×10^{-6}. At the higher moisture level (58 to 90 percent relative humidity), k is about three times higher.

The diffusion of moisture through wood in the absence of free water occurs generally through two pathways: as bound water through wood substance, and as water vapor through open capillaries (6). The rate of movement of the bound water through wood substance is markedly dependent on the moisture content level (4). The movement of vapor through the capillaries probably is less sensitive to moisture content, since it essentially is an unhindered diffusion. The 3-fold difference in k thus is due to the increase in the contribution of bound water diffusion to the overall diffusion.

At the lower humidity level, an acetyl content of about 8 percent completely eliminates the contributions to k caused by bound water movement. This is shown by the fact that, regard-

The Author: Harold Tarkow, a research chemist, holds a Ph.D. from the University of Wisconsin. He has been with the USFPL since 1943, concentrating primarily on adhesion and dimensional stabilization. S. M. Ishaq was a research assistant and collaborator from Pakistan at the time this work was conducted.

[1] A contributed paper received April 29, 1960; approved for publication November 9, 1960.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to Literature Cited at the end of this report.

Table 1.—STEADY STATE DIFFUSION OF MOISTURE THROUGH ACETYLATED AND UNTREATED YELLOW BIRCH VENEER

Relative Humidity Interval, Percent	Acetyl Content, Percent	k Gm./hr.cm.²/cm. mm. Hg	Reduction in k, Percent
35 to 75	0.0	*0.98 x 10^{-6}	
	7.9	0.60 x 10^{-6}	39
	9.8	0.67 x 10^{-6}	32
	15.8	0.55 x 10^{-6}	44
	19.6	0.51 x 10^{-6}	48
	25.0	0.62 x 10^{-6}	37
	Av.†	0.59 x 10^{-6}	40
58 to 90	0.0	*3.03 x 10^{-6}	
	9.8	1.22 x 10^{-6}	59
	15.8	0.87 x 10^{-6}	71
	18.2	0.82 x 10^{-6}	73
	18.4	0.79 x 10^{-6}	74
	25.1	0.73 x 10^{-6}	76

*Average of 3 values.
†Average values for treated specimens.

Table 2.—COMPARISON OF RATE OF PERMEATION OF MOISTURE THROUGH HIGHLY STABILIZED WOOD (ACETYLATED) AND THROUGH SYNTHETIC FILMS

Material	Thickness, Mils	k at given thickness, Gr./hr./cm.²/mm. Hg	Resistance Relative to that of Acetylated Wood
Untreated wood*	4.5	270 x 10_{-6}	0.25
Acetylated wood*	4.5	65 x 10_{-6}	1
Polyethylene terephthalate†			
Density: 1.33	4.5	1.5 x 10_{-6}	43
1.35	4.5	1.0 x 10_{-6}	65
1.37	4.5	0.8 x 10_{-6}	80
Polyethylene‡			
Density: 0.90	4.5	0.4 x 10_{-6}	160
0.98	4.5	0.25 x 10_{-6}	260
Paraffin wax (161 F. MP)§	0.5	0.04 x 10_{-6}	1,600

*Relative-humidity interval, 58 to 90 percent.
†From data of Lasoski and Cobbs (3). Relative humidity interval, 0 to 100 percent.
‡Data of Lasoski and Cobbs corrected for 4.5 mils thickness.
§From data of Fox (2). Relative humidity interval, 0 to 50 percent.

less of the degree of acetylation, k is roughly constant. The relatively uniform residual k (0.59 x 10^{-6}) is that due solely to vapor movement and accounts for 60 percent of the movement through untreated wood under these conditions. Bound water movement, which accounts for about 40 percent of the overall permeability constant in untreated wood under these conditions, has been essentially eliminated by the treatment. The residual rate of moisture movement is still relatively high even though the antishrink efficiency of the treated wood varies from 35 to 75 percent for acetyl contents varying from 8 to 25 percent (7). This may be surprising at first thought; however, chemical stabilization is achieved by modifying wood substance, whereas reduction in moisture permeability is achieved by reducing the movement in the wood substance as well as in the cell cavities.

Now, consider the permeabilities at the higher humidity level. The value of k is reduced by about 60 percent at approximately 10 percent acetyl content; however, there is some residual bound water movement, as shown by the fact that with increasing acetyl content, k continues to decrease. At 25 percent acetyl content, k is reduced about 75 percent. That is, the rate of movement of moisture through wood with an acetyl content of 25 percent (and under these conditions) is only about 25 percent that through the untreated wood. At the lower relative humidity level, the residual movement was 60 percent of that through the untreated wood. Bound water movement is more important at the higher humidity level than at the lower level. Since acetylation reduces only bound water movements, it would be expected to have a greater influence in reducing the overall permeability at high humidity levels rather than low levels.

Note that the residual k (0.73 x 10^{-6}) is approaching that of the vapor movement at the lower humidity level (0.59 x 10^{-6}). At an acetyl content where all bound water movement at the higher humidity level would cease, the two residual k values probably would be the same essentially. One would expect k to be independent of humidity level when only vapor diffusion occurs.

The reduction in k of 76 percent seems impressive and suggests consideration of the effectiveness of a layer of stabilized wood, around a thick untreated core, as a moisture barrier. Suppose a block of yellow birch is surface acetylated (25 percent acetyl) to a depth of 4 to 5 mils (equivalent to about 5 fiber-cell diameters). What is the permeability of this layer in contrast to that of a similar layer of untreated wood? If we assume a residual unit permeability through acetylated wood of 0.73 x 10^{-6}, the corresponding permeability through the 4-to-5-mil thick layer would be about 65 x 10^{-6} grams per hour per square centimeter per millimeter of mercury. One way to comprehend this value is to compare it with the permeability of moisture through synthetic films that theoretically could be applied to the surface of wood for moisture barrier purposes. These permeabilities were obtained from the literature. See Table 2.

Note that the low-density polyethylene terephthalate film is more than 40 times as effective a barrier as the same thickness of highly acetylated wood. Low-density polyethylene film is about 160 times more effective and the paraffin wax, at one-tenth the thickness of the acetylated layer, is about 1,600 times more effective. Chemical stabilization of the surface layers of wood, even to very high levels of antishrink efficiency, thus produces an inefficient moisture barrier. Stabilization merely eliminates bound-water diffusion through the treated wood. It has little effect on vapor diffusion through this layer. On the other hand, synthetic films surrounding wood should reduce the rates of both bound-water and water-vapor movements by reducing the rate with which moisture approaches the wood. The effectiveness of such films will depend on their physical integrity and on the characteristic rate with which moisture diffuses through them.

Conclusions

At low levels of relative humidity, bound-water diffusion through wood is completely eliminated by moderate chemical stabilization (35 percent antishrink efficiency). The residual transmission is that due to vapor movement through open capillaries. At high levels of relative humidity, bound-water diffusion decreases with increasing acetyl content, but even at the highest degree of stabilization (75 percent antishrink efficiency), some residual bound-water movement occurs. The greatest reduction in overall rate of transmission, nearly 80 percent, is still inadequate for imparting to wood a high degree of temporary protection if the acetylated portion is present as a thin surface layer. For equivalent thickness, coherent synthetic films are up to many hundred times more efficient as moisture barriers than a layer of highly chemically stabilized wood.

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Let's Integrate Our Markets Too![1]

Weyerhaeuser Company, Tacoma, Wash.
JOHN L. ARAM

Integration in our normal use of the term, is the combination of manufacturing processes that allows a firm to make the most complete utilization of the available raw material. Here's a new viewpoint—market integration. The two concepts are not mutually exclusive. To the contrary, as process integration is a means to maximum utilization of raw material, market integration is a means to maximum profit. Our industry must consider both as we seek ways to identify and satisfy the real needs of the customer.

INTEGRATION HAS BEEN DEFINED AS "the bringing together of parts into a whole." While it is not unusual for idealists of our industry to advocate integration of manufacturing processes for visionary purposes, the real purpose of integration of business within this industry is clear—it is to earn a higher return from the raw material used.

Over the years, the Weyerhaeuser Company has moved to integrate its production of a variety of products on a single plant site at our western processing centers. At the same time, certain necessary steps have been taken to provide the facilities and services necessary to serve our customers in an orderly manner. As a result of these activities, the public accords to the company its recognition for leadership in the field of resource utilization.

The Weyerhaeuser Company was incorporated at the turn of the century as a timberland owner. Although considerable timber was sold from the lands in the early days, the first 25 years of operation resulted in company construction or acquisition of only a few sawmills.

Horizontal integration—where products or uses other than lumber were made from logs—has been in progress at Weyerhaeuser since 1917 when hogged fuel was successfully converted to power, or since 1918 with completion of a shingle mill by Snoqualmie Falls Lumber Company.

The Author: With 20 years of forest industry experience, ranging from trainee to company president, John Aram joint Weyerhaeuser in 1956. He is now vice-president of research, Hardwood, and Silvatek. This division is responsible for manufacturing and marketing products made by dry forming of wood fibers, for corporate research, for the development of new products and processes unrelated to existing lines, and for Weyerhaeuser's integrated Hardwood operations acquired during 1960.

The Basic Product

Until the early 1930's, however, the company was geared to make one basic product . . . lumber. Utilization of all of the trees, low-grade logs, together with milling and logging leftovers, was impractical at the time because of uneconomical production and marketing conditions. Weyerhaeuser used some of the leftovers to supply hogged fuel for power plants—which produced power and large quantities of steam for the dry kilns,—on its millsites, but the waste burner was still a monument to an unsolved problem—how to recover maximum market values from harvested timber crops.

Process Integration

A bleached sulfite pulp mill constructed in 1931 was designed to utilize hemlock, white fir, and spruce logs in southern Washington. This represented the company's first step in diversification and process integration. It was followed by other company sulfite mills in Washington. The decision to build these mills was stimulated by the market need for a chemical wood pulp that could be made from small logs and trees—the products of which at that time were not accepted in lumber markets. Further plant integration took place during the 1930's when units were installed to produce compressed wood-fuel logs from dry sawdust and planer mill shavings.

The company was then on its way to grouping mills on plant sites. These plant sites were further integrated with sustainable capacity and production of nearby tree farms. In the 1940's, the company added plywood plants and initiated the pulping of bleached kraft market pulp from Douglas-fir sawmill leftovers. This was followed by construction of board units to produce containerboard, linerboard, and corrugated medium. Other plants now convert Douglas-fir bark into numerous commercial products and other products are manufactured from whole wood fibers.

More recently, utilization has been broadened by establishment of hardboard and particle board plants, by establishment of a Ply-Veneer plant (that marries the versatility and strengths of veneer and kraft pulp board) and a plant that produces chemicals for use in our own pulp mills.

Integration: A Means Not an End

While it is a dramatic story of wood utilization, I wish to re-emphasize that integration is a means to maximize profits—and is not an end in itself.

Whenever we see a new market demand, and as our researchers develop a new product or new combinations of present products to meet this demand, further product integration will take place within our company. There will be other new plants, either on existing millsites or in areas located to serve best our customers and to utilize available raw materials.

This brief and incomplete summary of plant integration within the company parallels in general the history of the forest products industry in the United States. It is a record of efforts to achieve utilization of the whole log, to increase the stumpage return by making saleable products from wood, and —by grouping mills on a single mill-

[1] Presented at FPRS Mid-South Section Meeting October 12, 1959 in Beaumont, Texas; approved for publication July 18, 1960.

site—to convert the entire harvest into products through more efficient operation (central local management, central power facilities, reduced transportation, and other methods of cost reduction). It may be concluded that, until the present time, product development within the company has followed a production-oriented philosophy.

Such integration will continue, but it is now necessary for the company, as with others in the industry, to find new ways to serve customers. Competition, principally from other materials, requires the expansion of product lines and services within the existing businesses of the company. This will require the extension of technical and sales services and other marketing activities, and the establishment of products that meet new market needs.

Marketing Concept

The justification for any business existence is to earn a profit by serving the needs and preferences of a market. As Peter Drucker has put it: "There is only one valid definition of business purpose: to create a customer." This has been described as a marketing concept. The marketing concept encompasses all activities required to facilitate the orderly serving of a satisfied customer integrated into one function. By necessity, Weyerhaeuser seems to be acquiring the philosophy of the marketing concept.

It is suggested that further developments require understanding and application of the marketing concept, a *market* orientation if you will, rather than a *production* orientation. Further, that research and commercialization activities in such fields as wood chemistry or other utilization must be balanced or integrated with silviculture and forest management. Finally, all these and subsequent functions performed in the business must be viewed and treated as parts of a marketing program designed to provide customers with specific products and services. Within this concept, then, it is the market that sanctions and influences all activities in the business which precede the final customer sale.

To Serve Consumer Needs

Whether you are concerned with product diversification achieved through resource integration, or whether you are concerned with product expansion through activities in the market, the purposes should be essentially the same: to serve and satisfy identified customer needs and preferences in your markets in such a manner as to increase the return from the land and the profits from manufacturing.

Integration serves no beneficial purpose when it is instituted to increase volume for the sake of volume. Development of a product without a clearly known market amounts to aimless and costly speculation.

Further integration of a forest products company's operation may be attempted when there has been provided a positive and accurate appraisal of customer needs and preferences in the market the company is capable of serving.

Successful Marketing = Further Integration

Here are some guide posts that may lead to successful marketing and further integration of the forest enterprise:

1. Define objectives clearly. If the purpose of utilizing forest residuals in a forest product is less than profit and growth of the business through serving a real market need, failure of the effort is assured. I emphasize this challenging concept of profit and growth because the process begins with the market.

2. Market only those products that can achieve customer acceptance and your own confidence. Weyerhaeuser development people enploy a "Use Requirements Analysis." Simply stated, this analysis injects the customer's viewpoint into the product development process. Every use that the product will be expected to serve is critically examined and clearly specified.

We believe that (1) the material must do a job that no other material can do successfully, or (2) for the same price, it must perform better than competing materials, or (3) at a lower cost, it must do as good a job as alternate materials, or (4) its unique characteristics must enable the manufacturer using the material to make corollary savings not possible with other materials. Use of this formula will permit management to develop products at a price that will pay . . . or it will prevent the tragedy of product failure.

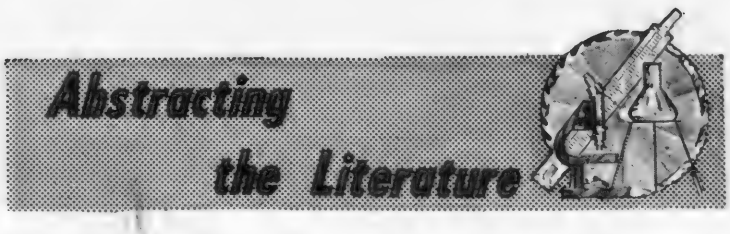
3. Organize to market the product. The present concept of "marketing" encompasses all of the activities required to facilitate the orderly serving of a satisfied customer, integrated into one function. The marketing function for any product, no matter how small the volume, requires that the following functions are managed: general management, research, production and quality control, merchandising, sales distribution, sales engineering, and product planning—including market research. With a single product just being started one person can do them all provided he does them all and well. Generally, several people with varying talents are needed. With clear objectives, and a good product, the concept of marketing management produces profitable results.

4. Do more with what you have today. One of our product objectives is "to make less wood go farther, do more, and in general, serve better." About us every day are unlimited opportunities to progress in this direction. These opportunities start with woods employees—less breakage in falling causes fewer chunks, no large dog holes in logs prevent losses, wood sawn evenly reduces shavings waste, a rotary lathe that cuts smoothly produces higher quality plywood, or particle board "on size" eliminates the waste of sanding. In another way it is often—not always, but often—just as easy to produce products as the customer wants them, as opposed to how he does not want them. Processes can be modified to improve quality in service, uniformity of product and reduction of weight and waste. Often product realization can be increased up to 10 percent for these values. Because wood products have lacked uniformity, over-engineering has been used to be sure that they are good enough and strong enough in place. There seems to be no end of opportunity to do better.

5. Seek new markets for forest products. The trend in nearly all forest products seems to be to use wood in combination with other material. New processes and technology make possible such combinations in futuristic shapes, forms, sizes, and characteristics. Competitors who have been invading wood's primary markets since World War II may soon find that wood in many forms has come to be a lower-cost, higher-use and better-service material than maerials such as light metals, glass, and solid plastics.

6. Keep a positive attitude toward forest utilization in profitable products. Without this positive point of view, vast quantities of valuable forest materials are wasted. This does not imply that there is always an economic use for all forest material. At given times and places, we know that this is not true. There is a slogan that reads, "The proper measure of a man's age is the degree of pain with which he receives a new idea." To improve utilization of the wood resource is to experience the thrill of improved economic well-being through increased forest utilization—often when some have considered that such was not possible. Obstructions appear insurmountable until someone wills to use the material in sufficient degree to find the way.

Our industry will have properly started to find the way to profitably integrate when we seek to identify and satisfy the real needs of the customer.



PRESSING

Vinogradov, Yu. N., Denisov, O. B., nd Traitel'man, G. Ya. Pressing of ood-particle board with spent sulfite fer- ientation liquor concentrate [as a binder].)erevoobrabatybayushchaya Prom. no. 3: 1–12 (1960); Referat. Zhur., Khim. no. 9: 564 (1960). [Russ. Abstr. only avail- ble]

Wood-particle board was made from the edium fraction of wood particles passing hrough a screen mesh of 10 × 10 and 2.5 × 2.5 mm. and dried to a moisture con- ent of 3–6%. The residual fermentation quor concentrate *(I)* used as a binder con- ained 45% dry solids. Boards were ob- ained contg. varying amts. of *I* and pressed t various temps. Their water resistance increased with increasing temp. of pressing. The opt. temp. for wood-particle board aving a d. of 0.6–0.8 g./cu. cm. was 220–230°. Increasing the amt. of the binder and prolonging the time of pressing at higher temps. further increased the water resist- ance of the board.

Ziedin'sh, I. O. A study of changes in the moisture content of wood-particle board during hot pressing. Trudy Inst. Lesokhoz. Problem i Khim. Drevesiny Akad. Nauk Latv. S.S.R. 18: 47–65 (1960); Refrat. Zhur., Khim. no. 20: 560 (1960). [Russ Abstr. only available]

The increase in the moisture content lay- ers of wood-particle board during hot press- ing is caused by condensation and move- ment of water from the surface layers to- ward the center. The phenomenon is inten- sified at high pressing temps. The highest increase in moisture content of the central layers is observed when the surface is mois- tened by spraying with water. With surface moistening, the pressing time is shorter than when the board is moistened through- out its thickness. The amt. of water used for spraying must be calcd. in accordance with the expected increase in moisture con- tent within the board, which is detd. by the board's thickness, d., and initial mois- ture content. The recommended amt., de- pending on the thickness and d., is 100–200 g./sq. m., at a pressing temp. of 170–180° C.

BOARD

Brendel, Manfred. The manufacture of air-layered particle boards. Holz–Zentr. 86, no. 41: 619–20 (April 5, 1960). [Ger]

The principle and practice of this proc- ess and the props. of the boards produced are outlined. Branchwood and other wood waste is chipped into particles of various dimensions, and the resulting chips are en- trained in a current of air and allowed to fall freely onto an endless conveyor belt in such a way that the heavier larger particles accumulate in the middle and the finer ones at the surface of the deposited web. Top-to-bottom symmetry is achieved by having the moving belt traverse two deposition zones with oppositely moving air jets. This process requires chips of better quality and uniformity than does the conventional mfr. of three-layer particle board from pre- screened chip sizes.

GLUES AND GLUING

Eliassaf, J., and Eirich, F. R. Creep studies on gelatin at 100% relative humid- ity. J. Appl. Polymer Sci. 4, no. 11: 200–2 (Sept.–Oct., 1960). [Fr. and Ger. sum.]

In order to understand the alleged poor performance of glue joints under heat and high humidity, the creep behavior of gela- tin films was studied at 100% R.H. Under a given load, the films either extended to an equil. length or broke. Equil. stress- strain curves were obtained at 26.5, 31.5, 36.5, and 46.5° C. At the lowest temp., the films showed essentially rubberlike be- havior. At the higher temps., they became stiffer, and were brittle at 46.5°. This be- havior is explained by a decreased uptake of atm. moisture with increased temp. At 26.5°, the amt. of water absorbed (27%) is sufficient to plasticize the gelatin, whereas the amt. absorbed at 46.5° (15%) does not suffice to modify the glasslike behavior of dry gelatin. These results indicate that the poor performance of gelatin glues under warm and humid conditions is not due to deliquescence (which occurs only on direct contact of gelatin with liquid water). Contrary to common expectations, glue joints do not melt at elevated temps. as long as they are not contacted by liquid water, but they can harden on drying and eventually fail because of strong hydro- thermally induced shrinkage stresses. Fail- ure under high humidity conditions may be caused by the temp. dropping below the dew point, in which case liquid water of condensation (and not atm. humidity) is the culprit. 9 ref.

IMPREGNATING

Yukna, A. D., and Ozolin'sh, A. P. Re- ducing the water absorption of wood-par- ticle board by the addition of petrolatum. Trudy Inst. Lesokhoz. Problem i Khim. Drevesiny Akad. Nauk Latv. S.S.R. 18: 67–70 (1960). Referat. Zhur., Khim. no. 20: 560 (1960). [Russ Abstr. only avail- able]

The replacement of paraffin by petro- latum for waterproofing particle board is recommended. Petrolatum can be added to the wood particles in the form of an emul- sion, or the particles can be sprayed with hot petrolatum. Spent sulfite liquor can be used as a binder for wood-particle board waterproofed with petrolatum.

EXTRANEOUS MATERIALS

Carlberg, G. L., and Kurth, E. F. Ex- tractives from the western true firs. Tappi 43, no. 12: 982–8 (Dec., 1960).

The extvs. from four sp. of western firs (Pacific silver fir, noble fir, white fir, and grand fir) were comparatively examd. for their cpn. in an attempt to find differences on which to base a distinguishing chem. test. No distinguishing differences were found in the extvs. from the wood of these sp. The extv. contents were low, and no terpenes or flavonoids were present. Alc.- sol. components were compared using IR and UV spectra, color reactions, and paper chromat. Spectral studies did not differen- tiate the sp., but indicated that the basic structural unit for all exts. was the flavan nucleus. Paper chromat. indicated that only Pacific silver fir may have a component that is different from the other sp. An extreme similarity was found in the cpn. of the ether and alc. exts. from these four sp. of fir. 23 ref.

SUPPLY AND PREPARATION

Crane, T. P., Jr., and Fassnacht, D. L. Summer storage of hardwood chips at Pen- sacola, Fla. Tappi 43, no. 12: 188–94A (Dec., 1960).

A study of the effects of outside storage of hardwood chips conducted at Pensacola, Fla., produced the flg. conclusions: Outside summer storage of oak chips in the South is feasible; losses in yield and pulp quality are no greater than those reptd. in round- wood (log) storage under similar condi- tions. Outside summer storage of gum chips is feasible, but losses in wood substance appear more serious than those reptd. in other sp. or in roundwood storage under similar conditions. Effects of storage on temp. and moisture in hardwood piles are similar to those observed in pine chip storage. Permanganate no. and proportion of screen rejects are not influenced by time in storage.

Schütt, Ch. Chemical debarking of trees. A review of literature. Paperi ja Puu 42, no. 11: 579–87, 591–6, 598 (Nov., 1960. [Engl.; Finn. sum.]

This extensive discn. and rev. of the lit. on chem. barking considers the adhesion of bark to wood (measurement of peeling resistance, seasonal variations, anatomical and biol. characs.), studies of chem. bark- ing (methods, time of trmt., chemicals, pulpwood sp. and their response, etc.), effects of chem. barking (changes in the tree, influence on pulp mfr. and other for- est prods., wildlife, and silviculture), eco- nomics, and pats. It is concluded that, despite promising results on exptl. and pilot scales, chem. barking has not yet achieved appln. on a pract. com. scale and does not yet offer serious competition to mech. barking. 134 ref.

NAMES in the NEWS

E. L. Bruce Company, hardwood flooring manufacturer, recently named **R. K. Magers** of Evanston, Ill., to head its central division.

At a recent meeting of the Council of the Wisconsin Academy of Sciences, Arts, and Letters, **Dr. F. L. Browne,** subject-matter specialist at the Forest Products Laboratory, Madison, Wis., was unanimously voted to honorary life membership.

United States Plywood's board of directors has elected **E. R. Montgomery** and **J. J. Clarson** comptroller and treasurer, respectively, according to S. W. Antoville, chairman. Mr. Montgomery joined the company in 1949, and Mr. Clarson joined in 1947.

W. D. Eisenhauer has formed a new company under the name of William D. Eisenhauer to engage in the wholesale distribution of forest products in the D.C., Maryland, and Virginia areas. He was at one time Eastern Sales Manager for the Timber Engineering Company, NLMA affiliate in Washington, D. C., and has been an FPRS member since 1947.

Ponderosa Pine Woodwork, trade association of Western pine producers and stock millwork manufacturers, has named **F. G. Johnson** of the Weyerhaeuser Company to head its advertising committee. The committee oversees all of the associations advertising and promotion programs.

R. O. Huffman, chairman of the board and president of Drexel Enterprises, Inc., has announced the following appointments: **E. P. Bounous** has been named director of engineering; **J. C. Liebhart** has been named director of purchasing, and **C. P. Reinhardt** has been named director of labor relations.

Dr. Arthur B. Anderson, chief of the Division of Forest Products Chemistry in the University of California's Forest Products Laboratory, Richmond, has been elected a Fellow of the British Institute of Wood Science. He was honored for his outstanding contributions to the field of wood chemistry and forest products utilization.

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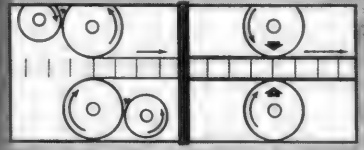

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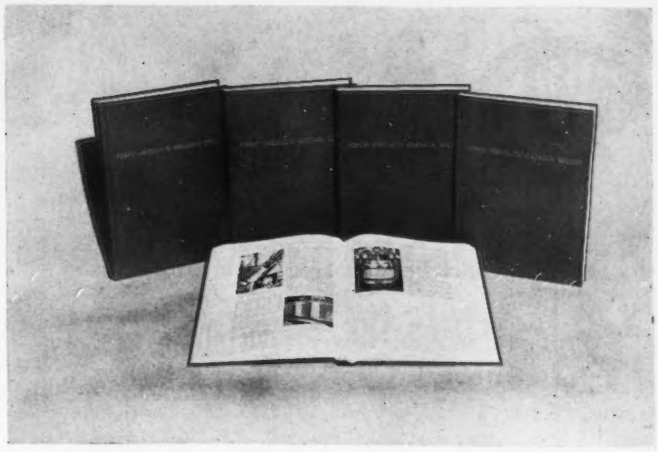

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1947—Vol. 1—UTILIZATION, ENGINEERING, PRESERVATION, SEASONING. 25 papers, 344 pp.

Articles cover: whole wood fiber manufacture; lignin chemistry; processing pine gum; paper and plastic overlays for veneer and plywood; integrated utilization; trends in logging; pulpwood logging developments in eastern Canada; building codes in postwar wood construction; engineering problems in prefabricated homes; postwar packaging field; functional furniture; postwar woodworking glues; metal to wood bonding; high frequency in woodworking; wood finishing; the use of car treated lumber; fence posts; an untapped market for the wood preserver; acid-proofing of wood; the artificial seasoning of wood in vapor of organic chemicals; kiln design; tungsten carbide developments; and tight cooperage plywood.

1948—Vol. II—UTILIZATION, FIBER PRODUCTS, BARKING, FINISHES, MACHINERY, R. F. HEATING. 50 papers, 500 pp.

Articles cover: economics of wood-waste utilization; losses in Redwood logging; small log gang sawmill; utilization of low-grade hardwood lumber; wood-distillation industry; sawdust carbonization; animal feeds from wood residue; small wood briquetting machine; special machines for utilization of waste slabs for glued core stock; interior trim from wood waste; wood-fiber production with revolving disk mills; effect of some manufacturing variables on the properties of fiberboard prepared from milled Douglas-Fir; small hydraulic log barker; mechanical methods of bark removal; studies on the chemical composition of bark and its utilization for structural boards; research in industry laboratories; history of furniture finishes; finishes resistant to alcohols and acids; low-bake synthetic finishes; simple testing methods for finishers; planning floor space for woodworking equipment; maintenance and operating practice for tungsten carbide tools.

1949—Vol. III—RAW MATERIAL, FURNITURE, PLYWOOD, UTILIZATION, GLUES, SEASONING. 55 papers, 607 pp.

Articles cover: more wood per acre; integrated wood utilization at Crossett; harvesting sawlogs; portable wood chippers; wood fibers from veneer waste; small permanent-type sawmills in better forest utilizatiton; pulpwood handling in the Lake States; tropical wood research for the furniture industry; effect of plywood glue lines on the accuracy of moisture-meter indications; No. 3 common Northern hardwood lumber for mechanized processing into glued products; cut stock from western softwoods; assembly material in furniture manufacture; supplementing wood with metal in furniture manufacturing; extending hot press urea resin with wheat and rye flour; furniture finishes; lumber core panels; rotary veneer cutting; molding plywood; insert-point circular headsaws; ills besetting the furniture industry; utilization of Redwood bark; utilization of waste sulfite liquor in concrete; semichemical pulping; dry-formed boards bonded with resins; wood, plywood and hardboard; compreg-resin-treated densified wood; wood preservatives; wood boring beetles; ignition temperatures of fireproofed wood, untreated sound wood, and untreated decayed wood; wood waste disposal and air pollution control in the Los Angeles area; pulp mill pollution; chemical composition of Ponderosa and Sugar Pine barks; lumber recovery from Douglas-Fir logs in British Columbia; resin adhesives; development of working stresses for stress-grade lumber; design and performance of laminated wood trusses, glued laminated wood, glued laminated Wej-weld frames; radio frequency heating.

1950—Vol. IV—MILLING, CONTAINERS, QUALITY CONTROL, PLYWOOD. 45 papers, 506 pp.

Articles cover: quality of second growth Douglas Fir; grading problems; quality control and the improved seasoning processes of the Redwood industry; saw teeth in action; lumber research to meet modern competition; hardwood log grading; recent developments in wirebound containers; method of utilizing and fabricating waste lumber; tests of strapped and lightweight lettuce crates; recent developments in containers; papermaking fibrous raw materials; utilization of low-grade hardwoods and softwoods; relation between wood and pulp properties; power vs. hand falling and bucking in logging operations; handling pulpwood; quality control in sawmill operations; hardwood plywood quality control; quality control in furniture production; defect detection equpiment non-destructive testing.

1951—Vol. V—MILLING, MACHINING, PRESERVATION, UTILIZATION, GLUES, KILN DRYING. 51 papers, 400 pp.

Articles cover: circular sawmills in the Tennessee Valley region; quality control in lumber manufacture, gangsaws in the manufacture of southern pine lumber; tropical hardwood production, logging and military equipment availability; defense and the availability of woodworking equipment; the importance of wood in the mobilization program; mobilization requirements for technical men in the woodworking industry; lumber conservation in military procurement and container design; military requirements for wood in packaging; wood requirements for specialized military uses; the place of small business in the military procurement program; marine laminating; selecting White Oak for bending lumber; machinability studies; carbide cutting tools in the wood industry; carbides; fire retardant treated lumber; wood preservation with particular reference to creosote; what the furniture industry expects from college-trained men; the scope and objectives of college training; graduate training in forest products technology.

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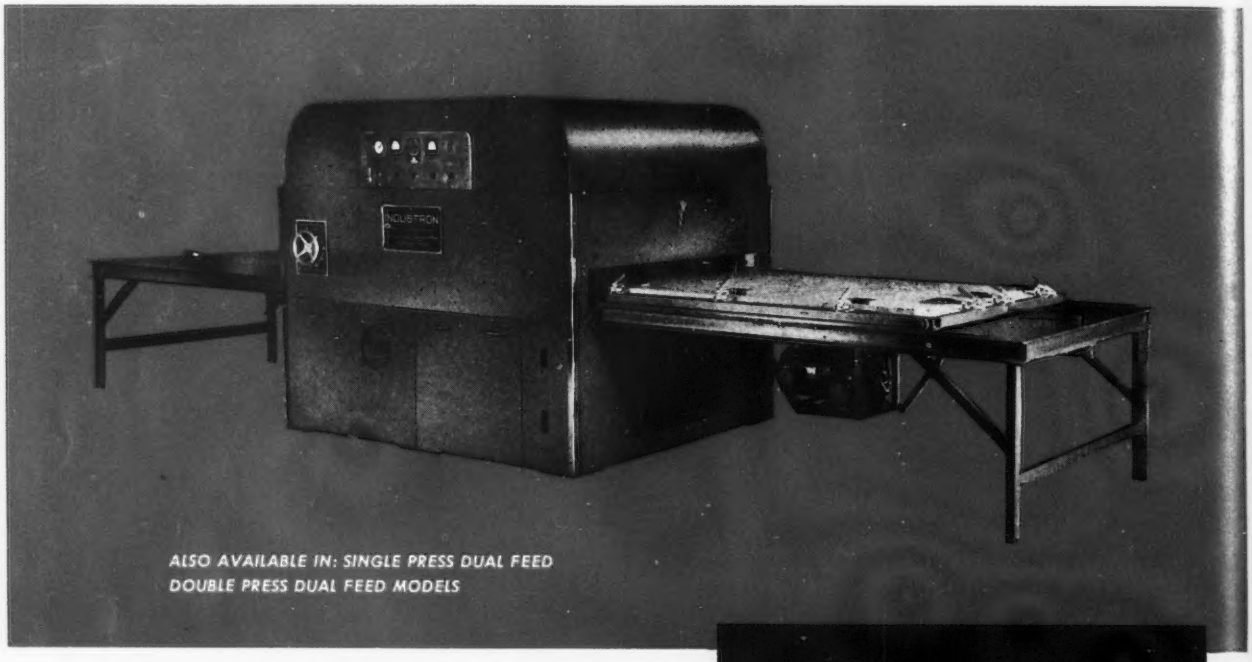

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